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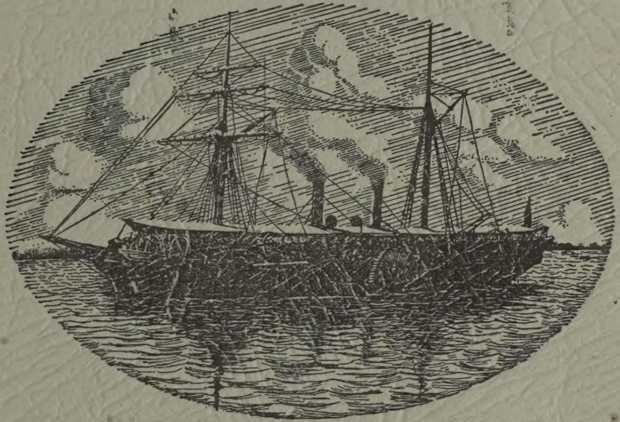

The Investigator

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Marine Biological Association of India

ABBREVIATION : *J. Mar. biol. Ass. India*

VOL. III June & December 1961 Nos. 1 & 2

CHARACTERISTICS OF SEA WATER NEAR THE LIGHT HOUSE, BOMBAY*

By R. JAYARAMAN,[1] R. VISWANATHAN[2] AND S. S. GOGATE[3]
Central Marine Fisheries Research Institute

As part of a programme of work on the distribution of surface temperatures and salinities in the Indian Ocean, sea water samples were collected regularly since 1936 near Prongs Reef Light House, Bombay (18° 53′N, 72° 48′ E). Besides temperature measurements and salinity determinations, estimations of dissolved oxygen, inorganic phosphate and total phosphorus, using standard methods (*vide*, Harvey, 1955), were also carried out on the samples. The results are shown graphically in Figs. 1 to 7.

The results appear to be of considerable interest since significant annual variations can be detected which can be correlated with similar variations in meteorological conditions. This applies, in particular, to the density of surface water which varies inversely with rainfall in the monsoon months (S.W. Monsoon) and with wind velocity during these months. The dominance of the south west monsoon and the influence of heavy rains along the west coast of India in decreasing the salinity of the surface water is well known and mention has been made of this by George (1953). Malurkar, Chaubal and Rao (1958) also found a close inverse correspondence between sea density (determined hydrometically) and the rainfall in the area when moving average values were used for comparison of the conditions prevailing at Alibag and Colaba. However, there was a time lag between high rainfall and the dilution to low density. This was attributed by these authors partially to a dynamic effect.

In the present instance, it is observed that wind velocity is possibly the more dominating factor. While the minimum in sea density corresponding to maximum in wind velocity is very sharp and characteristic, there is only one minimum instead of two which could be expected if rainfall were to be the more decisive factor (Fig. 6a). It is thus seen that the dilution and consequent reduction in density is due to an intrusion caused by winds rather than a localized effect due to rainfall. From a comparison of the hydrological and meteorological data for the two years 1958 and 1959 for Bombay and the corresponding data for the same years at Calicut, it is noted that at Calicut the minimum temperature was recorded in July while near Bombay this was observed in January and February. Further the lower range of surface salinity close to shore off Calicut—4°/₀₀ (Subrahmanyan, 1959) stands out sharply against the corresponding range of 10°/₀₀ and more for the Bombay region. These differences in salinity and temperature are probably related to variations in strength of shoreward drift (of course, caused by winds) of highly saline off-shore waters at the two places during the period of the South-West Monsoon (Jayaraman and Gogate, 1957).

---

* Published with the kind permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

Part of the material presented in this paper (1958-59 data) has been incorporated in the M.Sc. Thesis of one of us (S. S. Gogate).

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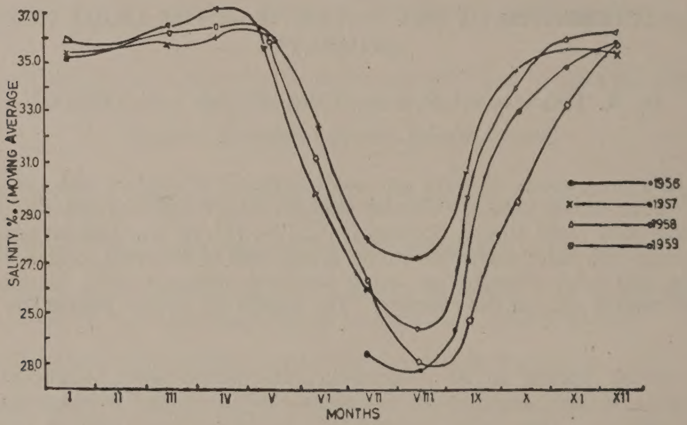
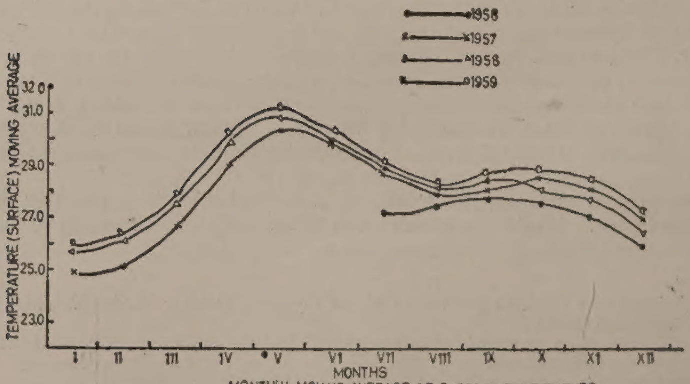


FIG. 1



MONTHLY MOVING AVERAGE OF SURFACE TEMPERATURE

FIG. 2

From the close association of such drift with rainfall, wind velocity and surface salinity, it would appear that low winds promote high surface salinities against the opposing dilution effect of rainfall. At Calicut wind velocity is small while off Bombay the wind velocity is much higher. The influence of wind velocity is confirmed by differences noticed in Bombay between conditions prevailing in 1958 and 1959.

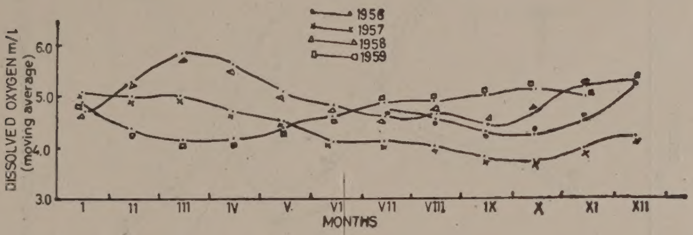


FIG. 3

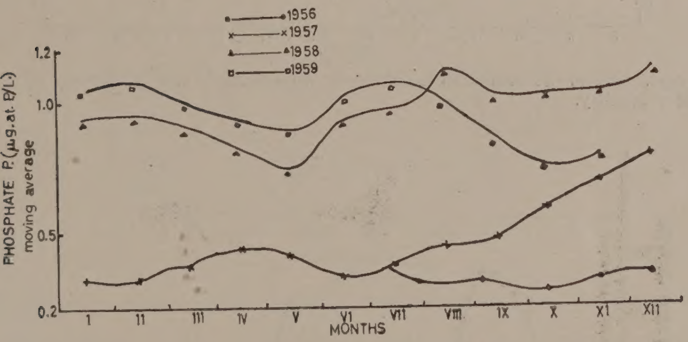


FIG. 4

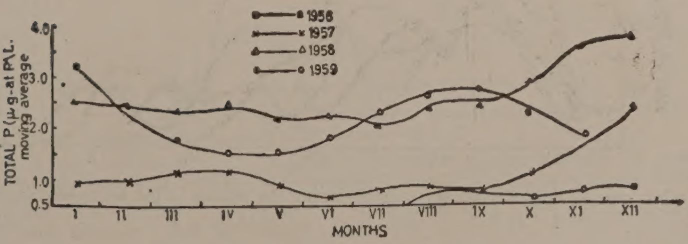


FIG. 5

FIGS. 1-5. Show the monthly variations (moving averages) in salinity, surface temperatures, dissolved oxygen, inorganic phosphate and total phosphorus respectively, in the inshore waters near Prongs Reef Light House, Bombay.

It is noteworthy that differences in meteorological conditions are reflected also in variations in biologically important compounds such as phosphates, dissolved oxygen, etc., (Figs. 1-5). These variations are of significance in view of their importance to plankton, plankton feeders and fisheries in general since it would appear that in certain regions there is a certain amount of correspondence between high rainfall and high fishery production (Dietrich and Kalle, 1957 ; Subrahmanyan, 1959).

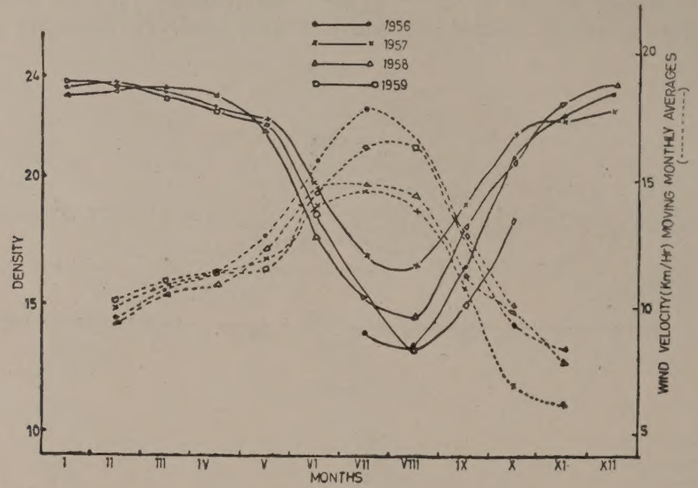


FIG. 6(a). Shows the comparative values for wind velocity and sea density in the different months near Bombay.

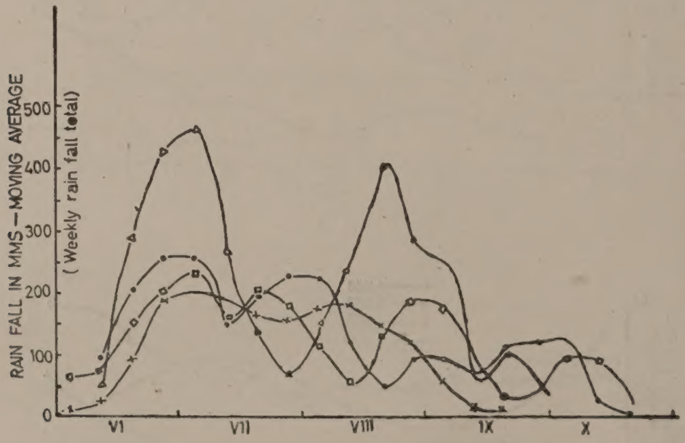


FIG. 6(b). Shows the total weekly rainfall during the period of the southwest monsoon near Bombay.

SUMMARY

An account of the hydrological conditions of the inshore waters off Prongs Reef Light House, Bombay is presented and discussed. Significant annual variations (between 1956 and 1959) in temperature, salinity and other biologically important factors are recorded. It is seen that these variations are related to the prevalent meteorological conditions, such as rainfall, winds, etc. There appears to be a greater degree of association between winds and variations in the hydrological condition.

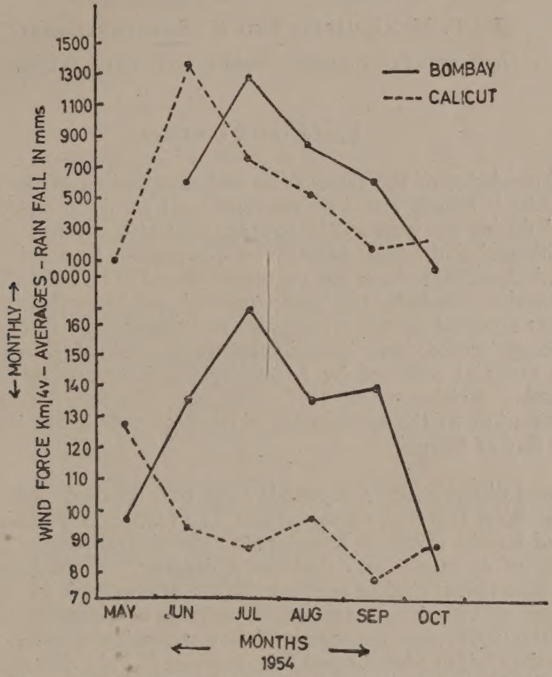


FIG. 7. Shows the comparison of wind velocity and rainfall data for Bombay and Calicut.

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THE SYSTEMATICS AND DISTRIBUTION OF PLANKTONIC COPEPODS IN THE LAWSON'S BAY, WALTAIR

By P. N. GANAPATI AND K. SHANTHAKUMARI
Department of Zoology, Andhra University, Waltair

INTRODUCTION

OUR present knowledge of the systematics and distribution of the copepods in the seas around India is largely based on the reports of plankton collected by R.I.M.S. 'Investigator' during the years 1910 to 1925 and also on the material collected during the 'Siboga' and 'John Murray' expeditions. Excellent accounts on the systematics and distribution have been given by Sewell (1912, 29a, 32, 40, 47, 48 and 49) on the collections made by the 'Investigator' and 'John Murray' Expeditions. Scott (1909) has reported on the systematics and distribution of copepods collected during the 'Siboga' expedition. Mention should be made of the work of Wolfenden (1906) on the material collected by J. Stanley Gardiner around the Maldive and Laccadive islands. Krishnaswamy (1951, 52a, 52b, 53a, 53b, 53c and 56) has made valuable contribution to the systematics of the copepods in the inshore waters off Madras in the Bay of Bengal.

The seasonal distribution of copepods have been studied by Jacob and Menon (1947) from the West Hill Sea, Ganapati and Rao (1954) off Waltair, Kartha (1959) and Prasad and Kartha (1959) at Mandapam. Jacob and Menon (1947) correlated the distribution of copepods with diatoms, hydrographical conditions and fisheries. Ganapati and Rao (1954) studied the distribution of copepods in space and time in the neritic waters off Visakhapatnam coast in relation to the salinity and temperature changes. Kartha (1959) gave an account of the distribution of copepodites and adults of copepods in the Gulf of Mannar and Palk Bay and found a difference in the species composition as well as populations of the adults in the two areas. Prasad and Kartha (1959) found a close relation between the breeding of copepods and the diatom cycles both in the Gulf of Mannar and Palk Bay.

Observations on the seasonal distribution of copepods along with general plankton investigations have been made by Menon (1931) ; Aiyar, Menon and Menon (1936) ; Ganapati and Sarma (1958) ; Prasad, Bapat and Tampi (1952) ; Prasad (1954, 56) Chacko (1950) ; Menon (1948) ; George (1953) and Bal and Pradhan (1945, 52).

In the present paper an attempt has been made to correlate the distribution of planktonic copepods in the inshore waters in the Lawson's Bay with the currents, salinity, temperature and diatom cycles.

MATERIAL AND METHODS

Surface plankton samples, collected thrice a week with an ordinary half-meter tow-net made of best Swiss organdy at about the 10 fathom line, in the Lawson's Bay during the years 1957, '58 and '59, were used in the present study.

By counting the number of copepods in three aliquot samples (10 cc. each), the total number of copepods present in a collection was calculated.

CLASSIFIED LIST OF COPEPODS

CALANOIDA

Family : CALANIDAE.
    Genus : *Nannocalanus* Sars.
        Nannocalanus minor (Claus).
    Genus : *Canthocalanus* A. Scott.
        Canthocalanus pauper (Giesbrecht).
    Genus : *Undinula* A. Scott.
        Undinula darwini (Lubbock).
        U. vulgaris (Dana).

Family : EUCALANIDAE.
    Genus : *Eucalanus* Dana.
        Eucalanus attenuatus (Dana).
        E. crassus Giesbrecht.
        E. elongatus (Dana).
        E. monachus Giesbrecht.
        E. mucronatus Giesbrecht.
        E. pseudattenuatus Sewell.
        E. subcrassus Giesbrecht.
    Genus : *Rhincalanus* Dana.
        Rhincalanus cornutus Dana.
        R. nasutus Giesbrecht.
    Genus : *Mecynocera* Thompson, I. C.
        Mecynocera clausi Thompson, I.C.

Family : PARACALANIDAE.
    Genus : *Paracalanus* Boeck.
        Paracalanus aculeatus Giesbrecht.
        P. parvus (Claus).
    Genus : *Acrocalanus* Giesbrecht.
        Acrocalanus gibber Giesbrecht.
        A. gracilis Giesbrecht.
        A. longicornis Giesbrecht.
        A. monachus Giesbrecht.

Family : PSEUDOCALANIDAE.
    Genus : *Clausocalanus* Giesbrecht.
        Clausocalanus arcuicornis (Dana).
    Genus : *Calocalanus* Giesbrecht.
        Calocalanus pavo (Dana).

Family : AETIDEIDAE.
    Genus : *Euaetideus* Sars.
        Euaetideus sp.

Genus : *Euchirella* Giesbrecht.
Euchirella bella Giesbrecht.
E. brevis Sars.
E. messinensis (Claus).

Family : EUCHAETIDAE.
Genus : *Euchaeta* Philippi.
Euchaeta marina (Prestandrea).

Family : SCOLECITHRICIDAE.
Genus : *Scolecithrix* Brady.
Scolecithrix danae (Lubbock).
Genus : *Scaphocalanus* Sars.
Scaphocalanus robustus (T. Scott).

Family : CENTROPAGIDAE.
Genus : *Centropages* Kroyer.
Centropages dorsispinatus Thompson and Scott.
C. furcatus (Dana).
C. gracilis (Dana).
C. orsinii Giesbrecht.
C. tenuiremis Thompson and Scott.
C. trispinosus Sewell.

Family : PSEUDODIAPTOMIDAE.
Genus : *Pseudodiaptomus* Heerick.
Pseudodiaptomus aurivilli Cleve.
Genus : *Schmackeria* Poppe and Richard.
Schmackeria serricaudatus (T. Scott).

Family : TEMORIDAE.
Genus : *Temora* Baird.
Temora discaudata Giesbrecht.
T. turbinata (Dana).

Family : METRIDIIDAE.
Genus : *Pleuromamma* Giesbrecht.
Pleuromamma abdominalis (Lubbock).

Family : LUCICUTIIDAE.
Genus : *Lucicutia* Giesbrecht.
Lucicutia flavicornis (Claus).
L. ovalis Wolfenden.

Family : HETERORHABDIDAE.
Genus : *Heterorhabdus* Giesbrecht.
Heterorhabdus spinifrons (Claus).

Family : AUGAPTILIDAE.
Genus : *Haloptilus* Giesbrecht.
Haloptilus longicornis (Claus).

Family : ARIETELLIDAE.
  Genus : *Metacalanus* Cleve.
    Metacalanus aurivilli Cleve.

Family : CANDACIIDAE.
  Genus : *Candacia* Dana.
    Candacia aethiopica (Dana).
    C. bradyii A. Scott.
    C. curta (Dana).
    C. discaudata A. Scott.
    C. pachydactyla (Dana).
    C. simplex Giesbrecht.
    C. turgida Wilson.

Family : PONTELLIDAE.
  Genus : *Labidocera* Lubbock.
    Labidocera acuta (Dana).
    L. acutifrons (Dana).
    L. bengalensis Krishnaswamy.
    L. detruncata (Dana).
    L. euchaeta Giesbrecht.
    L. kroyeri (Brady).
  Genus : *Pontella* Dana.
    Pontella andersoni Sewell.
    P. danae var. *ceylonica* Thompson and Scott.
    P. fera Dana.
    P. investigatoris Sewell.
    P. securifer Brady.
  Genus : *Pontellopsis* Brady.
    Pontellopsis armata (Giesbrecht).
    P. regalis (Dana).
    P. scotti Sewell.
  Genus : *Pontellina* Dana.
    Pontellina plumata Dana.
  Genus : *Calanopia* Dana.
    Calanopia elliptica (Dana).
    C. minor A. Scott.
    C. thompsoni A. Scott.

Family : ACARTIIDAE.
  Genus : *Acartia* Dana.
  Sub-genus : *Odontacartia* Steuer.
    Acartia (Odontacartia) erythraea Giesbrecht.
  Sub-genus : *Planktacartia* Steuer.
    Acartia (Planktacartia) danae Giesbrecht.
    A. (P.) negligens Dana.

Family : TORTANIDAE.
  Genus : *Tortanus* Giesbrecht.
    Tortanus forcipatus Giesbrecht.
    T. gracilis (Brady).

CYCLOPOIDA

Family : OITHONIDAE.
  Genus : *Oithona* Baird.
    Oithona linearis Giesbrecht.
    O. nana Giesbrecht.
    O. plumifera Baird.
    O. rigida Giesbrecht.
    O. robusta Giesbrecht.
    O. setigera (Dana).

Family : CLAUSIDIIDAE.
  Genus : *Saphirella* T. Scott.
    Saphirella sp.

Family : LICHOMOLGIDAE.
  Genus : *Macrochiron* Brady.
  Sub-genus : *Paramacrochiron* Sewell.
    Macrochiron (*Paramacrochiron*) *parvum* (A. Scott).
  Genus : *Pachysoma* Claus.
    Pachysoma punctatum (Claus).

Family : ONCAEIDAE.
  Genus : *Oncaea* Philippi.
    Oncaea conifera Giesbrecht.
    O. venusta Philippi.

Family : CORYCAEIDAE.
  Genus : *Corycaeus* Dana.
  Sub-genus : *Corycaeus* Dahl.
    Corycaeus (*Corycaeus*) *speciosus* Dana.
  Sub-genus : *Agetus* Kroyer.
    Corycaeus (*Agetus*) *limbatus* Brady.
  Sub-genus : *Onychocorycaeus* Dahl.
    Corycaeus (*Onychocorycaeus*) *giesbrechti* Dahl.
    C. (*O*) *ovalis* Claus.
  Sub-genus : *Urocorycaeus* Dahl.
    Corycaeus (*Urocorycaeus*) *furcifer* Claus.
  Sub-genus : *Corycella* Farran.
    Corycaeus (*Corycella*) *gibbulus* Giesbrecht.

Family : SAPPHIRINIDAE.
  Genus : *Sapphirina* Thompson.
    Sapphirina metallina Dana.
    S. nigromaculata Claus.
    S. opalina Dana.
    S. ovato-lanceolata Dana.
  Genus : *Copilia* Dana.
    Copilia mirabilis Dana.
    C. quadrata Dana.
    C. vitrea (Haeckel).

HARPACTICOIDA

Family : LONGIPEDIIDAE.
Genus : *Longipedia* Claus.
Longipedia scotti (Sars.).

Family : ECTINOSOMIDAE.
Genus : *Microsetella* Brady and Robertson.
Microsetella norvegica (Boeck).
M. rosea (Dana).

Family : PELTIDIIDAE.
Genus : *Alteutha* Baird.
Alteutha sewelli Krishnaswamy.

Family : DIOSACCIDAE.
Genus : *Diosaccus* Boeck.
Diosaccus hamiltoni Thompson & Scott.
D. truncatus Gurney.

Family : MACROSETELLIDAE.
Genus : *Miracia* Dana.
Miracia efferata T. Scott.
Genus : *Macrosetella* A. Scott.
Macrosetella gracilis (Dana).

Family : TACHIDIIDAE.
Genus : *Euterpina* Norman.
Euterpina acutifrons (Dana).

Family : CLYTEMNESTRIDAE.
Genus : *Clytemnestra* Dana.
Clytemnestra rostrata (Brady).

SEASONAL DISTRIBUTION OF COPEPODS

As many as 109 species of copepods have been identified and listed. The bulk of the copepod population is made up of the Calanoid genera *Canthocalanus*, *Eucalanus*, *Paracalanus*, *Acrocalanus*, *Clausocalanus*, *Centropages*, *Schmackeria* and *Acartia*, the Cyclopoids *Oithona*, *Oncaea* and *Corycaeus* and the Harpacticoid *Euterpina*.

The distribution of the various species during the different months of the year is given at the end of the paper. There has not been any marked deviation in the time of their appearance during the three years under observation and as such it was found unnecessary to indicate their distribution separately for each year. According to their occurrence the copepods could be grouped into the following 3 categories :—

(1) Species which occur either throughout the year or for most part of the year.

Canthocalanus pauper
Eucalanus subcrassus
Paracalanus aculeatus
Paracalanus parvus
Labidocera acuta
Calanopia elliptica
Acartia erythraea
Tortanus forcipatus

Acrocalanus gibber
Acrocalanus gracilis
Clausocalanus arcuicornis
Euchaeta marina
Centropages furcatus
Centropages dorsispinatus
Schmackeria serricaudatus
Temora discaudata

Oithona rigida
Oncaea conifera
Oncaea venusta
Corycaeus limbatus
Corycaeus ovalis
Corycaeus speciosus
Euterpina acutifrons
Macrosetella gracilis

Of these, six species occur throughout the year in good numbers and form the bulk of the copepod fauna. The others appear in large numbers only during certain months while being present in smaller numbers for most part of the year.

Paracalanus aculeatus and *P. parvus* have their maxima from January to April and again from July to September. *Schmackeria serricaudatus* occurs in maximum numbers in March and again in June and July. *Acartia erythraea* were observed in large numbers in May and August in 1957 and in March to April and again in June in 1958 and 1959. *Oithona rigida* is the dominant copepod during the February-June period. While *Euterpina acutifrons* showed three maxima in a year, February to March, July and September, the others show only two maxima.

(2) Species which occur only during certain months of the year:

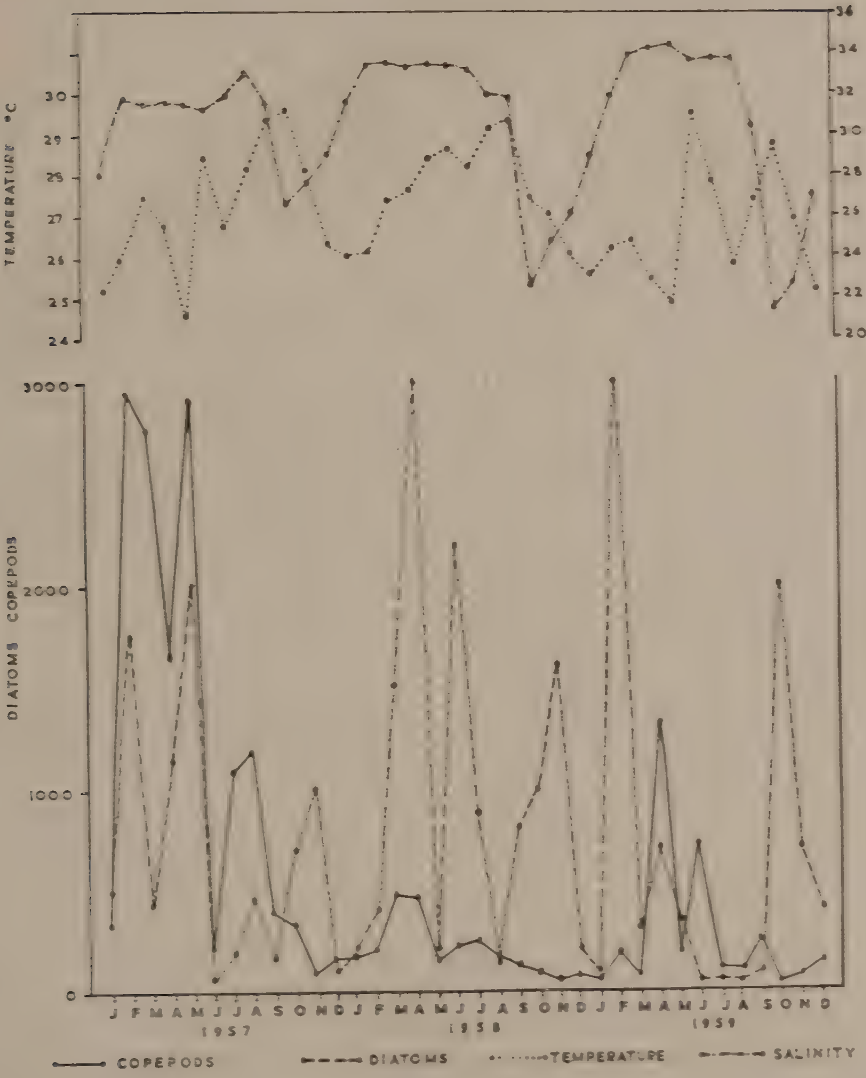
Undinula darwini
Undinula vulgaris
Eucalanus crassus
Mecynocera clausi
Acrocalanus longicornis
Calocalanus pavo
Centropages trispinosus
Centropages gracilis
Centropages tenuiremis
Centropages orsinii
Temora turbinata
Lucicutia flavicornis
Candacia aethiopica
Candacia discaudata
Labidocera bengalensis

Calanopia minor
Calanopia thompsoni
Oithona linearis
Oithona nana
Oithona plumifera
Oithona robusta
Oithona setigera
Macrochiron parvum
Corycaeus gibbulus
Corycaeus giesbrechti
Copilia mirabilis
Diosaccus truncatus
Sapphirina nigromaculata
Sapphirina ovatolanceolata
Clytemnestra rostrata

(3) Species which are very rare and occur sporadically in small numbers.

Eucalanus attenuatus
**Eucalanus elongatus*
**Eucalanus monachus*
Eucalanus mucronatus
Eucalanus pseudattenuatus
**Rhincalanus cornutus*
**Rhincalanus nasutus*
**Euaetideus* sp.
**Euchirella bella*
**Euchirella brevis*
**Euchirella messinensis*
**Scolecithrix danae*
**Pseudodiaptomus aurivilli*
**Scaphocalanus robustus*

**Labidocera euchaeta*
Labidocera kroyeri
Pontella andersoni
**Pontella danae* var. *ceylonica*
**Pontella fera*
**Pontella investigatoris*
**Pontella securifer*
**Pontellopsis armata*
Pontellopsis regalis
Pontellopsis scotti
Pontellina plumata
**Tortanus gracilis*
**Saphirella* sp.
**Pachysoma punctatum*



Text-Figure. The Copepods and Diatoms shown in the figure represent their number in 10 ml. of the plankton sample.

Pleuromamma abdominalis
Lucicutia ovalis
Haloptilus longicornis
Heterorhabdus spinifrons
Metacalanus aurivilli
Candacia bradyii
*_Candacia curta_
*_Candacia pachydactyla_
Candacia simplex
Candacia turgida
*_Labidocera acutifrons_
*_Labidocera detruncata_
Corycaeus furcifer
Sapphirina metallina
*_Sapphirina opalina_
Copilia quadrata
*_Copilia vitrea_
Longipedia scotti
*_Microsetella norvegica_
*_Microsetella rosea_
Alteutha sewelli
*_Diosaccus hamiltoni_
*_Miracia efferata_

It is interesting to note that those marked with an asterisk belonging to the class (3) are restricted to the Northerly current period, when the highly saline waters flow from the Malayan and Equatorial regions into the Bay.

A study of the seasonal distribution of the copepods during the different months of the year during the three-year period makes it possible to draw some general inferences. Text Fig. represents graphically the total copepod content in the plankton during the different months of the year together with diatom density, salinity and surface temperature for the same period. The copepod peaks in 1957 closely coincide with the diatom peaks except in the October-November months. There is also an inverse relationship of copepod abundance and temperature. It is interesting to observe that the copepod peaks are also during the months when the salinity conditions are high and steady. It is significant that even though the diatoms are abundant during the October-November period the copepod population is very low, owing to the prevailing low salinity and high temperature.

In 1958 the copepod numbers have been in general low, even though the diatoms did not show any corresponding fall. The salinity was also high and steady from January to July. The only explanation that could be offered for the low numbers of copepods for the year is the prevailing steady high temperature without the characteristic dips observed in 1957.

The pattern of distribution in 1959 is almost similar to that in 1957 with the periods of copepod abundance coinciding with steady high salinity conditions and low temperature.

Summary

1. Thirty-two families, comprising 48 genera and 109 species of copepods are recorded from the inshore waters off Waltair coast.

2. The density of copepod populations showed a direct relationship with diatom numbers and salinity and an inverse relationship with temperature.

3. The low numbers of copepods in 1958 is attributed to the prevailing high and steady temperature unlike the other two years.

COPEPOD CALENDAR

S. No.	Species of Copepods	J	F	M	A	M	J	J	A	S	O	N	D
	CALANOIDA												
1.	*Acartia danae* ..	—	—	—	—	R	—	—	R	—	—	—	—
2.	*A. erythraea* ..	R	R	R	F	R	R	R	F	R	R	R	R
3.	*A. negligens* ..	R	R	—	—	—	—	—	—	—	—	—	R
4.	*Acrocalanus gibber* ..	R	F	R	R	R	R	R	R	R	R	R	R
5.	*A. gracilis* ..	R	R	R	R	R	R	R	R	R	R	R	R
6.	*A. longicornis* ..	—	R	R	—	R	R	R	—	R	—	—	R
7.	*A. monachus* ..	—	R	—	R	—	—	—	—	—	R	—	R
8.	*Calanopia elliptica* ..	R	R	R	R	R	R	R	R	R	—	R	R
9.	*C. minor* ..	R	—	—	—	—	—	R	R	R	—	R	R
10.	*C. thompsoni* ..	R	—	R	R	R	R	—	—	—	R	—	—
11.	*Calocalanus pavo* ..	R	R	R	—	R	R	R	R	—	—	R	R
12.	*Candacia aethiopica* ..	R	—	R	—	R	—	—	—	R	R	R	—
13.	*C. bradyii* ..	—	—	—	R	—	—	—	R	—	—	—	R
14.	*C. curta* ..	—	—	—	R	—	—	—	—	—	—	—	—
15.	*C. discaudata* ..	—	—	R	—	—	—	—	R	—	R	R	R
16.	*C. pachydactyla* ..	—	—	R	R	—	—	—	—	—	—	—	—
17.	*C. simplex* ..	—	—	—	R	—	R	—	R	R	—	R	—
18.	*C. turgida* ..	R	—	—	R	—	—	R	—	—	—	—	—
19.	*Canthocalanus pauper* ..	R	R	F	R	R	F	R	R	R	R	R	R
20.	*Centropages dorsispinatus* ..	R	R	R	R	R	R	R	R	R	—	R	R
21.	*C. furcatus* ..	R	R	R	R	R	R	R	R	R	R	R	R
22.	*C. gracilis* ..	R	R	—	R	R	—	—	R	R	—	—	R
23.	*C. orsinii* ..	R	R	—	—	—	—	—	—	—	—	R	R
24.	*C. tenuiremis* ..	R	R	R	R	R	R	R	—	R	R	R	R
25.	*C. trispinosus* ..	R	—	R	R	R	R	—	R	R	R	R	R
26.	*Clausocalanus arcuicornis* ..	F	R	F	R	R	R	R	R	R	—	—	R
27.	*Euaetideus* sp. ..	—	—	—	R	—	—	—	—	—	—	—	—
28.	*Eucalanus attenuatus* ..	—	—	R	—	—	R	—	—	—	—	—	R
29.	*E. crassus* ..	—	R	R	—	R	—	R	R	—	—	—	R
30.	*E. elongatus* ..	—	R	R	—	R	—	—	—	—	—	—	—
31.	*E. monachus* ..	—	R	R	—	—	R	—	—	—	—	—	—
32.	*E. mucronatus* ..	—	R	—	—	—	R	—	—	R	—	—	—
33.	*E. pseudattenuatus* ..	—	—	—	R	—	—	—	R	R	—	—	—
34.	*E. subcrassus* ..	R	R	F	R	R	R	R	R	R	R	R	R
35.	*Euchaeta marina* ..	R	R	R	R	R	R	R	R	R	R	R	R
36.	*Euchirella bella* ..	—	—	R	R	—	—	—	—	—	—	—	—
37.	*E. brevis* ..	—	—	R	R	—	—	—	—	—	—	—	—
38.	*E. messinensis* ..	—	—	R	R	—	—	—	—	—	—	—	—
39.	*Haloptilus longicornis* ..	—	R	—	R	—	R	R	—	R	—	—	—
40.	*Heterorhabdus spinifrons* ..	—	—	—	R	—	—	—	R	R	—	—	—
41.	*Labidocera acuta* ..	R	—	R	—	R	—	R	R	R	R	R	—
42.	*L. acutifrons* ..	—	—	—	—	R	—	—	—	—	—	—	—
43.	*L. bengalensis* ..	—	—	—	R	R	R	R	R	R	R	—	R
44.	*L. detruncata* ..	—	—	—	R	R	—	—	—	—	—	—	—
45.	*L. euchaeta* ..	—	—	—	R	R	—	—	—	—	—	—	—
46.	*L. kroyeri* ..	—	—	R	—	R	—	—	—	—	—	R	R
47.	*Lucicutia flavicornis* ..	R	R	R	R	R	R	R	—	R	—	—	—
48.	*L. ovalis* ..	—	—	R	R	R	—	—	R	—	—	—	—
49.	*Mecynocera clausi* ..	R	R	R	—	R	—	R	—	R	—	—	R
50.	*Metacalanus aurivilli* ..	—	—	R	—	R	—	R	—	R	R	—	—
51.	*Nannocalanus minor* ..	—	—	—	—	—	—	—	—	—	—	—	R
52.	*Paracalanus aculeatus* ..	F	R	R	R	R	R	F	F	F	C	R	R
53.	*P. parvus* ..	F	R	R	R	R	R	R	R	R	R	R	R
54.	*Pleuromamma abdominalis* ..	—	R	—	R	—	R	R	—	R	—	—	—

R = 1-5 in 10 ml. sample
F = 6-20 -do-
C = 21 and above -do-

S. No.	Species of Copepods	J	F	M	A	M	J	J	A	S	O	N	D
55.	*Pontella andersoni*	R	—	—	—	—	—	—	—	—	—	—	R
56.	*P. danae* var. *ceylonica*	—	R	R	—	R	—	R	—	—	—	—	—
57.	*P. fera*	—	R	R	—	R	—	—	—	—	—	—	—
58.	*P. investigatoris*	—	R	R	—	R	—	—	—	—	—	—	—
59.	*P. securifer*	—	—	—	R	R	—	—	—	—	—	—	—
60.	*Pontellina plumata*	R	—	—	R	—	—	—	—	—	R	—	—
61.	*Pontellopsis armata*	—	—	—	R	—	—	—	—	—	—	—	—
62.	*P. regalis*	—	R	R	—	R	—	—	R	R	—	—	—
63.	*P. scotti*	—	—	—	R	—	—	—	—	R	—	R	—
64.	*Pseudodiaptomus aurivilli*	—	—	—	R	—	—	—	—	—	—	—	—
65.	*Rhincalanus cornutus*	—	—	—	R	R	—	—	—	—	—	—	—
66.	*R. nasutus*	—	—	—	R	—	—	—	—	—	—	—	—
67.	*Scaphocalanus robustus*	—	—	—	—	R	—	—	—	—	—	—	—
68.	*Schmackeria serricaudatus*	R	R	F	R	F	R	R	R	R	R	R	R
69.	*Scolecithrix danae*	—	—	—	R	—	—	—	—	—	—	—	—
70.	*Temora discaudata*	R	R	R	R	R	R	R	R	R	—	R	R
71.	*T. turbinata*	—	—	—	R	—	R	R	—	R	—	R	—
72.	*Tortanus forcipatus*	R	R	R	R	R	R	—	R	R	R	R	R
73.	*T. gracilis*	—	—	R	—	R	R	R	—	—	—	—	—
74.	*Undinula darwini*	R	—	R	R	R	—	R	R	—	R	—	R
75.	*U. vulgaris*	R	R	R	R	R	—	R	R	R	—	—	R
CYCLOPOIDA													
76.	*Copilia mirabilis*	R	—	—	R	—	R	R	R	—	—	—	R
77.	*C. quadrata*	—	—	—	—	—	—	R	—	R	—	—	—
78.	*C. vitrea*	—	—	R	—	—	—	—	—	—	—	—	—
79.	*Corycaeus furcifer*	—	—	R	—	—	—	—	—	R	—	—	—
80.	*C. gibbulus*	R	R	R	—	R	—	R	—	—	R	—	R
81.	*C. giesbrechti*	R	R	—	—	R	—	—	—	—	—	—	—
82.	*C. limbatus*	R	R	R	R	R	R	R	R	R	R	R	R
83.	*C. ovalis*	R	R	R	R	R	R	R	R	R	R	R	R
84.	*C. speciosus*	R	R	R	R	R	R	R	R	R	R	R	R
85.	*Macrochiron parvum*	R	R	R	R	R	R	R	R	R	—	R	R
86.	*Oithona linearis*	—	—	R	—	R	—	R	R	—	—	—	—
87.	*O. nana*	R	R	R	R	—	R	R	—	—	R	—	—
88.	*O. plumifera*	R	R	R	R	R	R	R	R	R	—	—	R
89.	*O. rigida*	F	C	C	C	C	F	F	R	R	R	R	R
90.	*O. robusta*	—	—	R	—	—	R	R	R	R	—	—	—
91.	*O. setigera*	—	R	R	R	R	—	R	R	R	—	—	R
92.	*Oncaea conifera*	R	R	R	R	R	R	R	R	R	R	R	R
93.	*O. venusta*	R	R	R	R	R	R	R	R	R	R	R	R
94.	*Pachysoma punctatum*	—	—	R	R	—	—	—	—	—	—	—	—
95.	*Saphirella* sp.	—	—	—	R	—	R	—	—	—	—	—	—
96.	*Sapphirina metallina*	R	—	R	R	—	—	—	—	R	—	—	—
97.	*S. nigromaculata*	R	—	R	R	R	R	R	R	R	—	—	—
98.	*S. opalina*	—	—	R	—	—	—	—	—	—	—	—	—
99.	*S. ovatolanceolata*	R	—	—	R	—	R	R	R	—	—	—	R
HARPACTICOIDA													
100.	*Alteutha sewelli*	—	—	R	R	R	—	R	R	—	—	—	—
101.	*Clytemnestra rostrata*	R	—	R	R	—	—	R	R	R	—	R	—
102.	*Diosaccus hamiltoni*	—	—	R	—	—	—	—	—	—	—	—	—
103.	*D. truncatus*	R	R	—	—	R	R	—	—	—	—	—	—
104.	*Euterpina acutifrons*	R	F	F	F	F	R	F	R	R	R	R	R
105.	*Longipedia scotti*	—	—	R	—	R	—	—	R	R	—	—	—
106.	*Macrosetella gracilis*	R	R	R	R	R	R	R	R	R	R	R	R
107.	*Microsetella norvegica*	—	—	—	—	R	R	R	—	—	—	—	—
108.	*M. rosea*	—	—	R	—	—	—	—	—	—	—	—	—
109.	*Miracia efferata*	R	—	R	R	R	—	R	—	—	—	—	—

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STUDIES ON INDIAN COPEPODS 5. ON ELEVEN NEW SPECIES OF MARINE CYCLOPOID COPEPODS FROM THE SOUTH-EAST COAST OF INDIA*

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INTRODUCTION

SEWELL (1949) has pointed out that our knowledge of the cyclopoid copepods of Indian waters, especially those inhabiting the littoral regions in association with invertebrates and sea weeds and in which the type of existence is usually referred to as ' semi-parasitic ', is extremely scanty. The oldest account available on this little known crustacean group in our waters is that of Thompson & Scott (1903) who, in their supplementary reports of the faunistic survey of the Pearl Banks of Ceylon, gave brief description of the copepods they came across. The cyclopoid copepods they dealt with were mostly obtained by examination of washings from dredged materials such as ascidians, sponges, corals, pearl oysters etc. Although the exact depth at which they were caught is not given in specific instances it is presumably from sea bottoms, at least a few fathoms deep. ' This collection of copepods have proved to be exceedingly rich and varied, containing as it does, no less than 283 species, of which 76 are new to science while at least 10 new genera are required ' (Thomp. & Scott, *loc. cit.*). Of these copepods, the ' semi-parasitic ' cyclopoids were one of the richest groups ; it was represented by 42 species of which 25 were new and no less than six new genera were required to accommodate eight of the new species. The only other exhaustive work on these tiny creatures in the Indian waters is that of Sewell (*loc. cit.*) who described the species obtained during the John Murray Expedition and also those he gathered during the long years of his valuable service in this country in the Marine Survey of India. He recorded 44 species belonging to this group, out of which 25 were new and 3 new genera and 2 sub-genera, had to be created to include some of the new species. Krishnaswamy (1954) recently reported three species from Madras coast ; all the three are new to our waters and one of them is new to science. Attention may be drawn here to the 2 new genera of cyclopoid copepods that have recently been reported from this area (Ummerkutty, 1960a and 1960b).

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The present paper deals with the following new species of copepods :—

(1) *Asteropontius littoralis*
(2) *A. sewelli*
(3) *Cryptopontius graciloides*
(4) *C. orientalis*
(5) *Hemicyclops intermedius*
(6) *Pseudoanthessius agilis*
(7) *Macrochiron* (*Macrochiron*) *rigida*
(8) *Lichomolgus holothuriae*
(9) *L. serratipes*
(10) *L. brevifurcatus*
and (11) *L. indicus*.

It is of interest to note that many of the copepods recorded or discovered from the Ceylon Pearl Oyster Grounds by Thompson & Scott about 60 years back have now been obtained by me from the Indian side of the Gulf of Mannar. A detailed account of these species will be published elsewhere.

Gooding (1957) has pointed out the undesirability of referring these animals collectively under such terms as ' parasitic ', ' semi-parasitic ', ' commensal ' etc., for there is little definite evidence about the nature of the association and little work to this end has been done on the copepods. Sars (1918) who first referred to their parasitic existence has qualified his statement by adding that ' in most cases, however, the parasitism may be merely temporary '. The fact is that most of the species are found to occur in association with a variety of hosts and the exact relationship between the copepod and the associated invertebrate is yet to be investigated in specific cases. Because of this ambiguity in their relationships I have preferred to refer to them as ' associated with invertebrates ' instead of referring them as parasitic or semi-parasitic. In the present collection only *Lichomolgus holothuriae* was found constantly to live inside the body cavity of *Holothuria sp.* Although there is no positive evidence that it is not found in association with other invertebrates, quite a number of holothurians examined yielded this copepod. *P. serratipes* was obtained from the washings of *Pteroeides esperi* Herklots, the common sea-pen of this coast. *Asteropontius littoralis* was obtained mostly from washings of weeds and mud-covered coral stones. Whether it has any relation with the Polychaetes observed to inhabit the same niche is not clear. Of the species discussed below, the following are represented by both the sexes.

(1) *Cryptopontius orientalis*
(2) *Pseudoanthessius agilis*
(3) *Macrochiron* (*Macrochiron*) *rigida*
(4) *Lichomolgus holothuriae*
(5) *L. brevifurcatus*
and (6) *L. indicus*

In describing the various body segments I have mainly adopted the terminology suggested by Gooding (*loc. cit.*) with some alterations (Ummerkutty, 1960 a & b).

In the section Siphonostoma all the cephalosomal appendages are easily distinguishable ; but in the section Poecilostoma there is a reduction in the mouth-parts and the homology of the various appendages has been a source of discussion among the carcinologists. Brady (1880) considered that the mandible, the maxillule (first maxilla), the maxilla and the maxilliped are present ; and this view has been shared by great many of the subsequent workers. [Gurney, 1927 ; Nicholls, 1944 ; Sewell (*loc. cit.*) and Gooding (*loc. cit.*)] However, Sars (*loc. cit.*) held a different view. He maintained that the mandible is absent in all the Poecilostoma and what is usually described as mandible is nothing but ' a part of the foremost pair having been erroneously taken for an independent limb '. At least as far as the family Clausidiidae is concerned Nicholls (*loc. cit.*) has shown beyond doubt that there are four pairs of oral appendages present : ' The few specimens of *Hemicyclops* found in this collection have been dissected with particular attention as to whether these two anterior pairs of mouth-parts came away together or were attached separately. In each case I found no attachment between them and during dissection observed that they were independently mounted side by side on the supporting skeleton. I am, therefore, convinced that there are two separate appendages : the mandible, which has the typical shape of such an appendage though lacking a palp and having a somewhat specialized armature and the maxillule, which is here distinctly cleft, the smaller lobe armed with strong spines representing the gnathobase, the larger lobe with setae only being the palp ' (p. 44). Gurney (*loc. cit.*) goes further and states that even in Lichomolgidae, the mandible and its ' palp ' are separable and can be recognized as distinct appendages.

As to the oral appendages of lichomolgids that are dealt with in this paper it is clear that all the four pairs are present, although highly reduced in some cases. In all cases, however, the mandible and the maxillule are very closely set. The drawings of these appendages have been made together. In describing the various appendages I have confined to the usage of those terms which are currently in vogue among the copepodologists. The terms protopod, exopod and endopod are used to indicate the basal, the external and the internal components respectively. These terms have been employed to describe not only the swimming legs but also the cephalosomal appendages.

MATERIAL AND METHODS

The material of the present study was obtained from the Gulf of Mannar and the Palk Bay on the south-east coast of India off Mandapam. Some of the species were found to occur in both the areas. Others were caught only in one of the two seas. All the collections were made in the inshore waters with a maximum depth of two meters and the period of collections was spread over from May to August 1960. The following method was adopted for the collection : Weeds, mud-covered coral stone, sponges, holothurians, starfishes etc. etc., were vigorously washed separately into hand-nets made of organdie cloth. Smaller mud particles were sifted out by repeated dipping of the net into sea water. The remaining portion was transferred to large glass jars and preserved in formalin. Larger non-copepod items were later hand-picked and discarded. The copepods were sorted out by examining the residue under a binocular microscope. Attempts to pick out some of the copepods alive seldom meet with success as they tend invariably to hide under some coverage, thus making it difficult to spot them. All the species are present in fairly good numbers. The type specimens are deposited at the Reference Collection

Museum of the Central Marine Fisheries Research Institute, Mandapam Camp. The description and the diagrams are based on the examination of more than one specimen. All the drawings have been made with the aid of a *camera lucida*.

Section SIPHONOSTOMA

Family Asterocheridae Giesbrecht s. str.

(Syn. Ascomyzontidae Sars)

Sars, 1918, p. 83.
Nicholls, 1944, p. 16.

Genus *Asteropontius* Thompson & Scott 1903

Thompson & Scott, 1903, p. 288.

Asteropontius littoralis sp. nov.

Material examined—Many specimens were collected during the months of June and July 1960. Most of the specimens were obtained from the Palk Bay off Mandapam and a few examples were also caught near the Pamban bridge, the meeting place of Gulf of Mannar and Palk Bay. The holotype and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered Nos. J. 535/4 and J. 536/4 respectively.

Description:

A. Female

The body (Fig. I, 1): The general appearance is typically asterocherid. The prosome is distinctly oval and is composed of four segments. The first segment is longer than the length of all other segments combined. The latter diminish gradually in width, the last of them being less than half as wide as the first. The urosome (Fig. I, 12) is only half the length of the prosome and consists of the fifth leg-bearing segment, the genital segment and two abdominal segments. The genital segment is the largest and has its anterior region wider than the posterior; at the junction of these two, there are tufts of hairs on either side. Urosomal segments are wider in front, gradually narrowing posteriorwards. Each caudal ramus bears six setae, one of which is distinctly longer than the entire urosome.

Antennule (Fig. I, 2) is 19-segmented and reaches to the posterior margin of the first prosomal segment. The segments of the antennule are divisible into a wider proximal and a narrower distal region, consisting of nine and ten segments respectively. All the segments are provided with setae, more than one in many cases, especially on ninth to eleventh segments where there is a profusion of setae. The eighteenth segment bears a fairly long aesthetask. The proportions of the various segments are given below (All segments are measured through the middle line).

1	2	3	4	5	6	7	8	9	10	
13.2	2.6	3.1	4.0	3.5	3.3	4.4	4.4	4.4	1.8	
11	12	13	14	15	16	17	18	19		
2.6	5.3	6.6	7.0	5.3	6.2	5.9	7.0	9.4		= 100

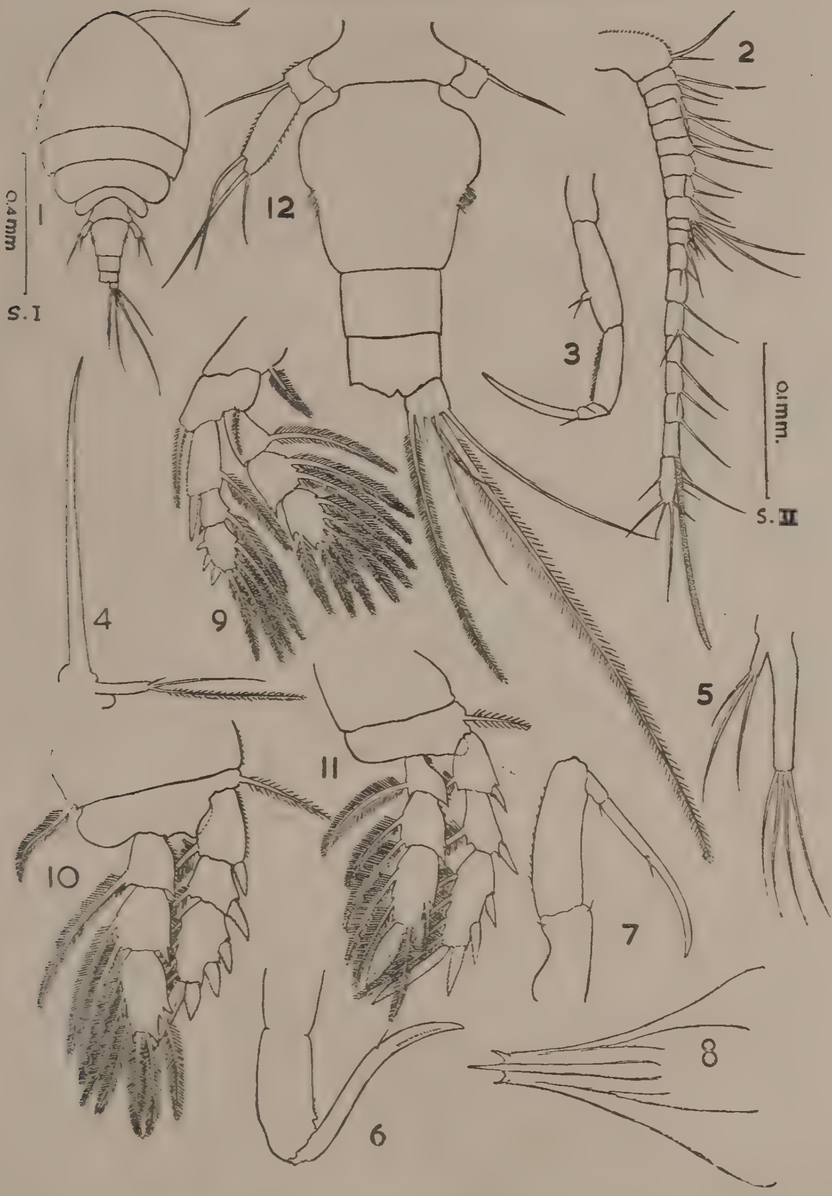

Figure I, 1-12. *Asteropontius littoralis* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, mandible.
5. ,, ,, maxillule.
6. ,, ,, maxilla.
7. Adult, female, maxilliped.
8. ,, ,, siphon.
9. ,, ,, first swimming leg.
10. ,, ,, second swimming leg.
11. ,, ,, fourth swimming leg.
12. ,, ,, urosome with the fifth leg.

(Diagram 1 is drawn according to scale I and diagrams 2-12 according to scale II).

Antenna (Fig. I. 3) is 5-segmented ; the last two segments, however, are not fully segmented. The second segment is the largest, the third, first, fourth and the fifth coming next in order. The second segment bears at about two-third of its length a rudimentary endopod which carries two small setae on the apex. The terminal antennal segment bears a fairly large spine and a stout seta at its apex. Hairs are present on the inner margin of the third segment. *Siphon* (Fig. I. 8) is stoutly built, pyriform in shape and only extending to the insertions of the maxillipeds ; its posterior edge is marked by three sharply spine-like structures, one medial and two lateral. *Mandible* (Fig. I. 4) is with a very long masticatory blade and a short uniarticulate palp which bears at its apex three setae of unequal length. The blade is five times as long as the palp. This condition is not found in any other known species of this genus. *Maxillule* (Fig. I. 5), as usual, is composed of two lobes which are much unequal in size. Both the lobes are provided with a number of apical setae which are rather strong and finely ciliated. *Maxilla* and *maxilliped* (Fig. I. 6 & 7) are of the usual asterocherid pattern, the only notable difference being that in the former the line of separation between first and second segments are not distinct although there is a clear constriction between them.

The four pairs of *swimming legs* (Fig. I. 9, 10 & 11) are borne by the four prosomal segments. They are all biramous, each ramus being composed of three segments. In the first legs, the basal exopod segment is elongated, almost equivalent to the combined length of second and third segments. The spine on that segment also is quite long. The second and third legs are very similar to each other in structural details and are quite normal. In the fourth leg the segments of both endopod and exopod are slender and long and differ from those of the preceding legs in setation. The setal formula of the four pairs of swimming legs are given below :—(In this and in all the subsequent accounts of the ornamentation of the swimming legs the following abbreviations have been used : P_1—P_4 stand for the first to the fourth swimming legs and Si, Se and St represent the internal, the external and the terminal margins respectively of the constituting segments. The setae are indicated in Arabic and the spines in Roman numbers).

	Protopod				**Endopod**							**Exopod**						
	1		**2**		**1**		**2**		**3**			**1**		**2**		**3**		
	Si	**Se**	**Si**	**Se**	**Si**	**Se**	**Si**	**Se**	**Si**	**St**	**Se**	**Si**	**Se**	**Si**	**Se**	**Si**	**St**	**Se**
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	2	III
P_2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	II	II
P_3	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	II	II
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	4	II	II

The fifth leg (Fig. I, 12) is quite moderate in size, reaching upto the middle of the genital segment. It consists of two segments of unequal size ; the basal bears a single seta and the distal three setae, two of which are apical and the third subapical. Stiff hairs are present on the outer margin of the basal and on both margins of the distal segment. The size of the adult female is 0.8 mm.

B. Male

Unknown.

Asteropontius sewelli sp. nov.

Material examined—Four specimens were obtained from the washings of the bottom weeds from Palk Bay in June 1960. All are females. The holotype and the paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and have the registered Nos. J. 569/5 and J. 570/5 respectively.

Description: **A. Female**

The body (Fig. II. 1)—Like the preceding species, here also, the body is more or less oval. The first prosomal segment is, however, much wider and longer than the other three segments combined. The urosome consists of four segments, the genital segment being the largest. The latter is vase-like, with the anterior part wider than the posterior and the two areas being separated by tufts of hairs on the lateral margins. The post-genital segments are cylindrical and narrow. The caudal ramus is short and distinctly smaller than the last abdominal segment : each ramus bears six setae, the longest of them being one and a half times longer than the entire urosome ; it is 2-segmented and profusely setiferous.

The antennule (Fig. II, 2) is fairly long reaching to the posterior margin of the first prosomal segment. It consists of nineteen segments, the first nine segments being distinctly wider and longer than the remaining segments. The eighteenth segment bears an aesthetask which is rather short. The proportionate lengths of the antennular segments are as follows :—

	1	2	3	4	5	6	7	8	9	
	8.69	3.00	2.55	2.78	2.55	2.33	2.21	2.55	2.33	
10	11	12	13	14	15	16	17	18	19	
1.23	1.47	5.85	7.36	8.69	8.69	9.49	8.68	9.75	9.81	= 100

Antenna (Fig. II, 3)—is 5-segmented and quite normal in structure. The second segment bears the rudimentary endopod : there are two short spines and a long spine on the terminal segment. *Siphon* (Fig. II. 4) is very short and stout, having two sharp needle-like points at the posterior tip : no medial spine is present. In the *mandible* (Fig. II. 5) the masticatory blade is very long and pointed while the palp is uniarticulate and rather short, bearing two setae, one of which is extremely long, being longer than the masticatory blade and ciliated on both margins. *Maxillule* (Fig. II. 6) consists of two lobes which are very much unequal in size, the smaller one being only one-fifth of the larger and appearing more as a process of the latter. *Maxilla* and *maxilliped* (Fig. II. 7 & 8) are quite normal and similar to those of the preceding species. The terminal claw of the maxilla, however, is much more slender and long.

Of the four pairs of *swimming legs* (Fig. II. 9, 10 & 11) which are borne by the four prosomal segments respectively, the first leg is the smallest. The second and

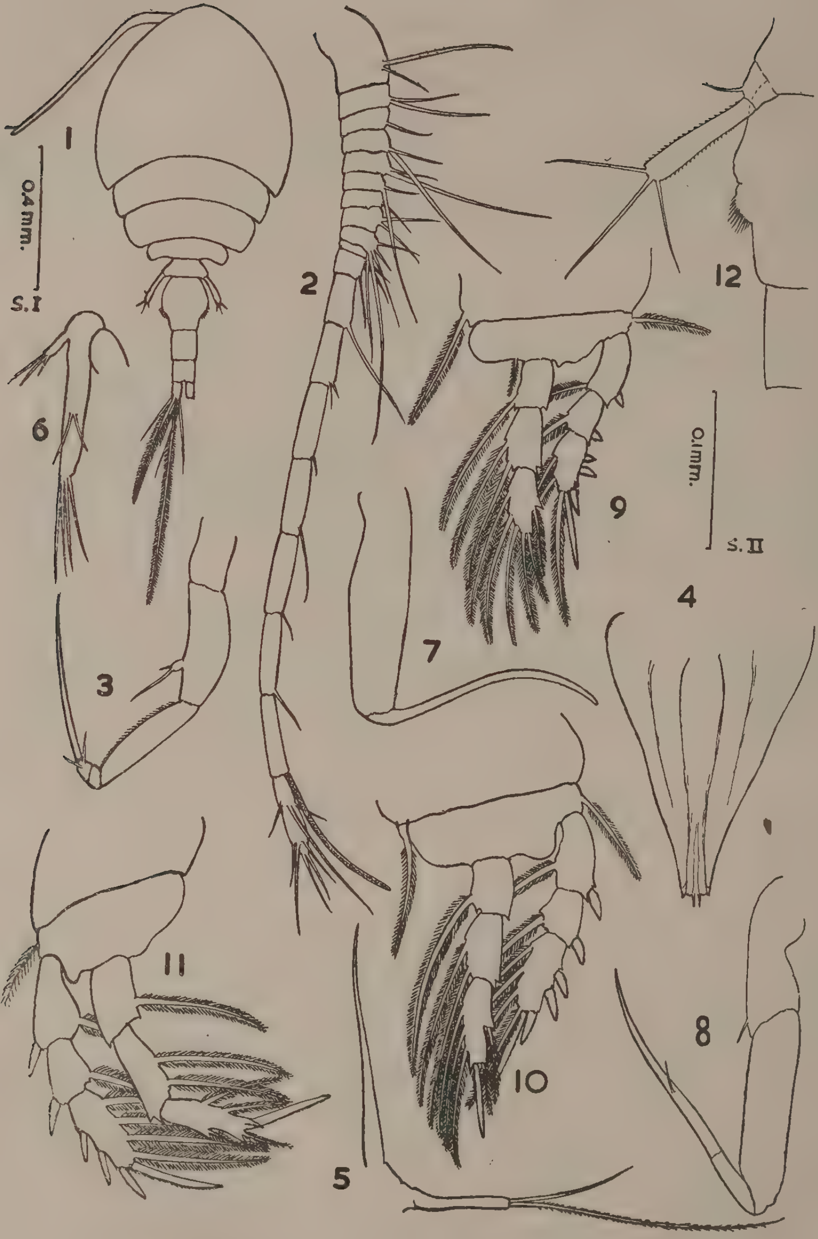

Figure II, 1-12. *Asteropontius sewelli*, sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, siphon.
5. ,, ,, mandible.
6. ,, ,, maxillule.
7. Adult, female, maxilla.
8. ,, ,, maxilliped.
9. ,, ,, first swimming leg.
10. ,, ,, second swimming leg.
11. ,, ,, fourth swimming leg.
12. ,, ,, fifth leg with parts of urosome.

(Diagram 1 drawn according to scale I and diagrams 2-12 according to scale II).

third legs are exactly similar in structure and appearance. In the fourth leg the constituting segments are longer than those of the preceding legs. The setal formula of the swimming legs is as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	1	1	1	0	2	0	3	2	1	1	I	1	I	2	1+I	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	II
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	4	I	II
P_4	0	0	0	1	1	0	2	0	2	I+1	1	1	I	1	I	4	I	III

It may be seen from the above that the terminal endopod segment in the second, third and fourth pairs of legs bears one seta and one spine instead of the usual single spine or single seta. The fifth leg (Fig. II, 12) is fairly long and thin and is 2-segmented, the proximal segment being contained about four times in the distal segment ; the former bears a single seta at its postero-lateral corner and the latter three radiating setae on the apex. There are stiff hairs on either margins of the distal segment. The size of the female is 1.1 mm.

B. Male

Unknown.

This species is named after Col. R. B. S. Sewell, C.I.E., SC.D., F.R.S., in recognition of the very valuable contributions that he has made towards our understanding of the Indian copepods.

Remarks—Thompson & Scott (1903) created this genus to include two species of copepods, *A. typicus* and *A. attenuatus* which they obtained from the sponge and invertebrate washings. Since then two more species have been added, *A. nicobaricus* Sewell from Nicobar Islands and *A. mycalei* Krishnaswamy, from Madras. The genus is very closely related to *Asterocheres* and can be distinguished only on careful examination. Thompson & Scott defined the genus *Asteropontius* as follows : ‘ Cephalothorax roundly ovate, five-jointed, the cephalic segment larger than the combined length of the four following segments. Anterior antenna 18-19 jointed. Abdomen 3-jointed. Outer branch of the posterior antenna 4-jointed, a small 1-jointed branch springing from the first joint. Maxilla 2-branched. Mandible long and narrow ; palp i-jointed. Maxilliped and natatory legs 1st to 5th as in *Asterocheres* ’ (*loc. cit.* p. 288). They remarked at the end of the description of *A. typicus* that ‘ the species bears a general resemblance to *Asterocheres*, but the 19-jointed antennae and the 1-jointed mandible palp separate therefrom.’ The antennular segmentation does not hold valid as a generic character for the number of segments in the antennule is now established to vary from eighteen to twenty in *Asteropontius* and fourteen to twenty in *Asterocheres*. The statement that the antenna is 4-jointed and that the rudimentary endopod is borne by the basal antennal segment does not conform to their diagrams (Pl. XVIII, Fig. 13 & Pl. XIX, Fig. 3) which clearly show that antenna is 5-jointed in both the species, and that the rudimentary endopod is borne by the second segment. In *A. nicobaricus* the antenna is 5-jointed, the proportions of the different segments being almost identical with those of the preceding two species. *A. mycalei* has an antenna which is 3-jointed ; it appears from the diagram of the latter species that the last two segments have undergone a fusion. The fact, however, is clear that as far as the segmentation of the antenna is concerned no distinction can be made between the two genera. Thus the only distinguishing feature of the genus *Asteropontius*, not shared by *Asterocheres*, is the uniarticulate nature of the mandibular palp.

The third segment of the first exopod also deserves some comments. Three types of conditions are met with in the present genus. In *A. typicus* there are four setae and two spines. In *A. attenuatus* the number of setae are four and that of spines three ; this latter condition is also found in *A. nicobaricus* and *A. littoralis* sp. nov. A third type of situation occurs in *A. mycalei* and *A. sewelli* sp. nov. ; here there are three setae and four spines. Thus the tendency towards an increase in the number of spines is accompanied by a reversed tendency in the case of setae.

Krishnaswamy (*loc. cit.*) has provided a key to the identification of the different species known upto that time. The number of segments of the antennule was the main criterion on which his key was based. It now appears that the number of setae and spines on the third segment of the first exopod also provides a good point of specific distinction and the identification key is here revised employing these two characters along with the structure of the caudal rami when it is required.

Key to the identification of the females

1.	Antennule composed of 18 segments	2
	Antennule composed of 19 segments	3
	Antennule composed of 20 segments	*A. mycalei* Krishnaswamy, 1954.
2.	Caudal rami longer than wide, the proportions of length and width being 5 : 2	*A. attenuates* Thomp. & Scott, 1903.
	Caudal rami wider than long, the proportions of length and width being 4 : 5	*A. nicobaricus* Sewell, 1949.
3.	The third segment of first exopod with four setae and two spines	*A. typicus* Thomp. & Scott. 1903.
	The third segment of first exopod with four setae and three spines	*A. littoralis* sp. nov.
	The third segment of first exopod with three setae and four spines	*A. sewelli* sp. nov.

Family DYSPONTIIDAE SARS

Sars, 1918, p. 117.

Nicholls, 1944, p. 23.

Genus *Cryptopontius* GIESBRECHT, 1899

Sars, 1918, p. 120.

Nicholls, 1944, p. 24.

Cryptopontius Graciloides SP. NOV.

Material examined.—Fourteen female specimens were obtained from washings of weeds from the Palk Bay. They were captured on two occasions. No specimen was available from the Gulf of Mannar even after many searches. The holotype and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J. 572/6 and J. 573/6 respectively.

Description: A. FEMALE

The body (Fig. III, 1).—The prosome consists of four segments and the urosome of five segments. The first prosomal segment is very large being distinctly larger than the rest of the body. It is slightly wider than long and the length-breadth proportion is 48 : 52. Second and third segments are less wide than the first segment but still with epimeral plates which are crowded together and curved backwards. The last prosomal segment is very small without epimeral plates and partly concealed by the preceding segment. The first segment of the urosome bears the highly reduced fifth pair of legs. It is only about as large as the last prosomal segment. The genital segment (Fig. III, 8) is quite large, being equivalent in length to the combined length of the three following segments. Its anterior part is very much widened, more than twice as wide as the last abdominal segment, and bears on each side a pair of spines towards the postero-lateral margin of the widened area. Of the three abdominal segments the first is the longest, and the second the shortest. They diminish in width posteriorly. The caudal ramus is a little wider than long and bears six setae, one of which is very long, being more than twice as long as the entire urosome ; the furcal setae are plumose.

Antennule (Fig. III, 2) is 9-segmented and rather stout. The first, third and the last segments are fairly long ; second segment is the shortest and is distinctly wider than long ; the fifth segment is square. Other segments are of moderate length and are longer than wide. The last segment bears an aesthetask which is about two-third the length of the antennule itself. Following are the proportions of the different segments :—

1	2	3	4	5	6	7	8	9		
18.2	3.8	19.5	7.2	6.0	8.3	8.3	9.8	18.9	=	100

Antenna (Fig. III, 3) is 4-segmented, the second segment carrying a rudimentary endopod bearing a single terminal seta. The second, third and fourth segments are of about equal lengths while the basal segment is distinctly shorter. The terminal segment bears three setae, one at about its mid-length on the ventral side and the

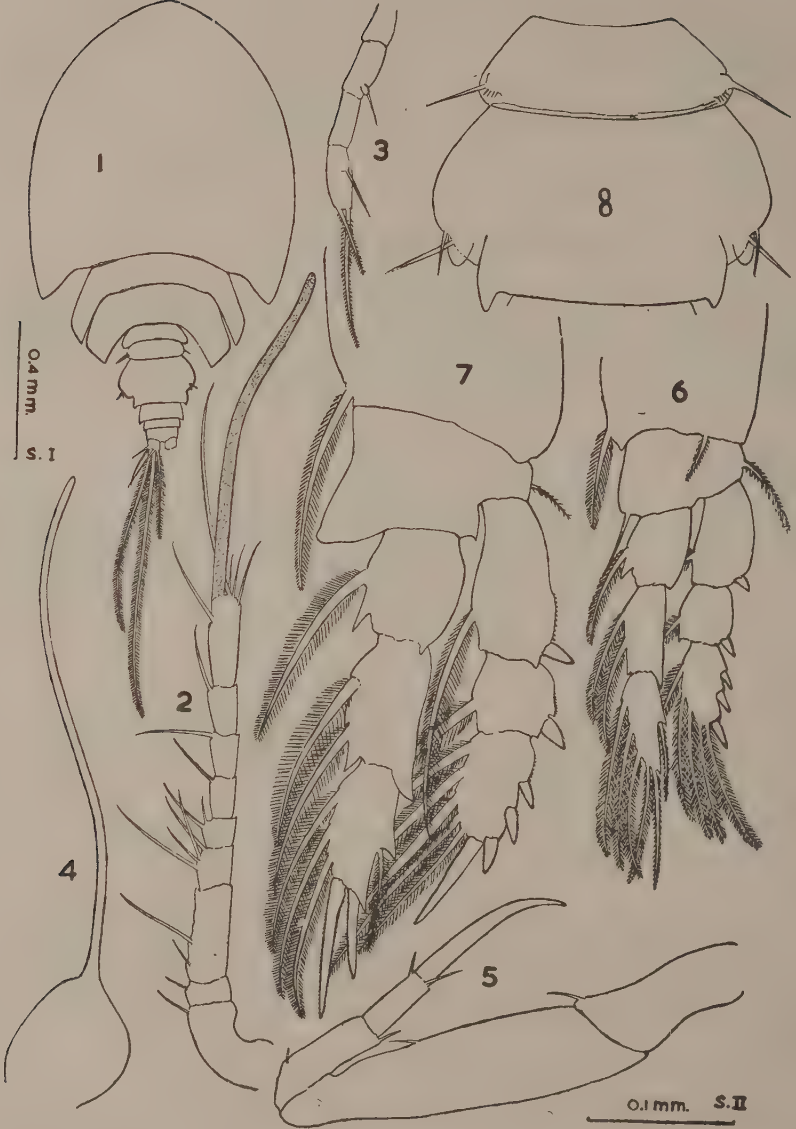

Figure III, 1-8. *Cryptopontius graciloides*, sp. nov.

1 Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, siphon.
5. Adult, female, maxilliped.
6. ,, ,, first swimming leg.
7. ,, ,, second swimming leg.
8. ,, ,, fifth leg with parts of urosome.

(Diagram 1 is drawn according to scale I and diagrams 2-8 according to scale II).

other two terminally ; the terminal setae are of unequal length. *Siphon* (Fig. III, 4) is extremely slender and consists of a bulbous proximal portion and a narrow distal portion which is of uniform thickness throughout and which extends almost to the end of the prosome. *Mandible* without any palp, masticatory blade slender, styliform and long. *Maxillule* (Fig. IV, 1) has both lobes slender, the outer more than three-fourth as long as the inner and armed with a very short spine and a fairly long seta ; the inner lobe bears on its apex a spine, and a seta, the latter being more than one and a half times longer than the lobe itself and provided with stiff hairs on the inner margin. The *maxillae* and *maxillipeds* (Fig. IV, 2 & III, 5) are normal in structure and resemble those of the type species of the genus.

The four pairs of swimming legs (Fig. III, 6, 7 and Fig. IV, 3) are borne by the four prosomal segments respectively. First three pairs are biramous while the fourth is uniramous, the endopod entirely lacking. While the second and third legs are similar to each other in structure and size, the first is distinctly smaller and shows differences in the setation. The setal formula of the swimming legs is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	1	I	1	1	0	2	0	4	1	1	1	I	1	I	4	1	III
P_2	1	0	0	1	1	0	2	0	3	II	1	1	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	II	1	1	I	1	I	5	1	III
P_4	0	0	0	0	Absent							1	I	1	I	5	I	III

The fifth legs (Fig. III, 8) are extremely rudimentary and are represented on each side by a single seta borne on a bud-like protrusion ; there are a few stiff hairs on the lower margin of this bud. The size of the female is 1.3 mm.

B. Male

Unknown.

Cryptopontius orientalis sp. nov.

Material examined.—Along with the preceding species, two female examples, each carrying a pair of beautifully rose-coloured ovisacs were obtained from Palk Bay in June, 1960. A few weeks after that some more examples, about fifteen specimens, were caught near the Pamban Bridge and the latter collection included both males and females. The type specimens, the holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J 658/7, J 659/7 and J 660/7 respectively.

Description:

A. Female

Although the ovisacs are of fine rose colour, the body is dull opaque, as in most of the cyclopoides. The ovisacs also lost their colour after a few days of preservation in formalin. *The body* (Fig. IV, 4)—This is more robust than in the preceding

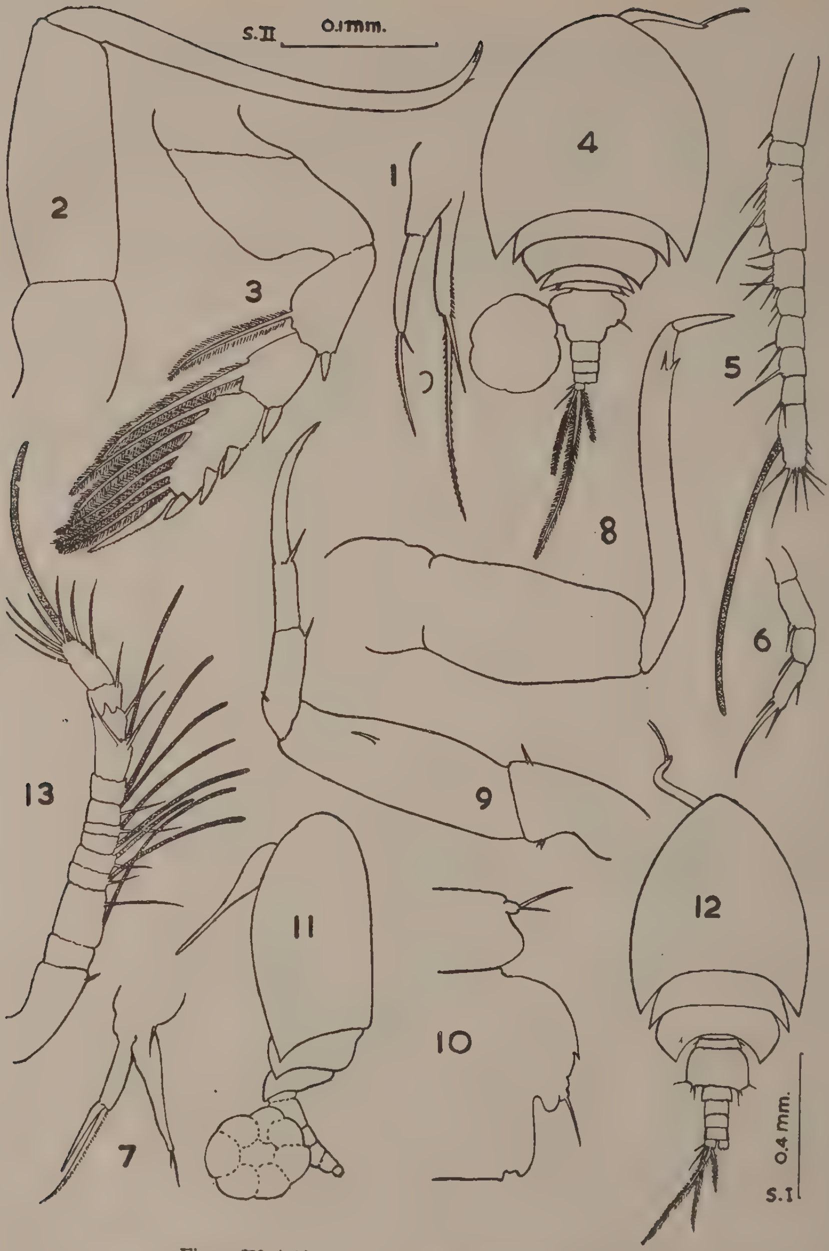

Figure IV, 1-13. *Cryptopontius graciloides* sp. nov.

1. Adult, female, maxillule.
2. ,, ,, maxilla.
3. Adult, female, fourth swimming leg.

Cryptopontius orientalis sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, antenna.
7. ,, ,, maxillule.
8. ,, ,, maxilla.
9. Adult, female, maxilliped.
10. ,, ,, fifth leg with parts of urosome.
11. ,, ,, lateral view.
12. Adult, male, dorsal view.
13. ,, ,, antennule.

(The fourth, eleventh and twelfth diagrams are drawn according to scale I and others according to scale II).

species and the first prosomal segment still constitutes the major part of the body. It is wider than long and is one-quarter time longer than the entire remainder of the body. Second and third prosomal segments are less wide but are provided with epimeral plates. The last segment is very small both in length and width and is without an epimeral plate but is provided with posterior angular corners like the preceding segments. The urosome is 5-segmented and is much similar to that of the earlier species. The anterior part of the genital segment, however, is comparatively wider. Although the three abdominal segments diminish in size posteriorly, the ratio of the length is different from that of the earlier species. The caudal rami are wider than long, each bears five setae, two of them appearing more like spines ; the longest seta is one and a half times longer than the entire urosome.

Antennule (Fig. IV, 5) is 9-segmented, the third segment showing a slight partial division. Segments 1-3, 5 and 9 are of the same length-width relations as in the preceding species, while the fourth, sixth, seventh and eighth segments are much shorter and are only a little longer than wide. The last segment bears an aesthetask which is about three-fourth as long as the entire antennule. The proportionate lengths of the constituting segments are :—

1	2	3	4	5	6	7	8	9		
22.0	5.1	19.8	8.8	6.9	7.8	6.9	6.9	15.8	=	100

Antenna (Fig. IV, 6) is 4-segmented, the second segment bearing the rudimentary endopod. The basal segment is equivalent to the third in length and is shorter than the second and fourth which are more or less of equal dimensions. While the third segment bears a single seta, the fourth has four of them, one at about half its length and three terminally. The setae are unequal in size. *Mandible* is quite normal and typical of the genus. *Maxillule* (Fig. IV, 7) has both lobes slender, the outer two-third as long as the inner and armed with a seta and a spine ; the inner lobe armed with two slender spines ; at the base of the inner lobe there is another spine. *Maxilla* and *maxilliped* (Fig. IV, 8 & 9) bear a great resemblance to those of the earlier species. A notable difference in the maxilla, however, is that the division between the first and the second segment is incomplete. In the maxilliped, the basal segment bears a pair of small spines on the outer distal margin, in addition to the one present on the inner distal margin.

First three pairs of swimming legs (Fig. V, 1, 2 & 3) are biramous, while the fourth is uniramous, the endopod entirely missing. The legs two and three are absolutely identical in structure and size, while the first leg is smaller. The outer margins of all the segments of the exopods of second, third and fourth legs are clearly dentate. The setal formula for the swimming legs is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	4	1	1	1	I	1	I	3	1	III
P_2	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	3	I+1	1	1	I	1	I	5	I	III
P_4	0	0	0	0	Absent							1	I	1	I	5	I	III

The number of setae and spines of the third segment of first exopod is different from that of the earlier species ; while in the latter there are five setae and three spines, here the number of setae is reduced to four. Further the setae on the inner side of the third endopod segment of the first leg is very small compared to that of the earlier species. *Fifth leg* (Fig. IV, 10) is highly reduced in size and it is represented on each side by a protrusion which bears two slender setae at its apex. The size of the female is 1.05 mm.

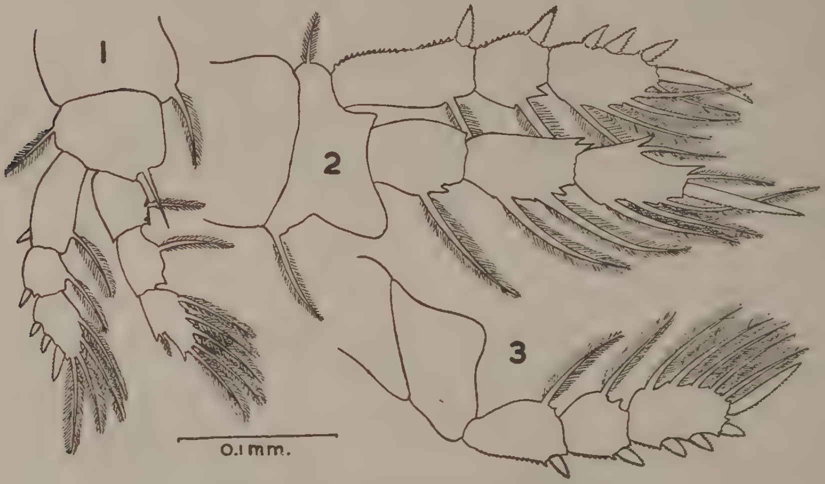

Figure V, 1-3. *Cryptopontius orientalis* sp. nov.

1. Adult, female, first swimming leg.
2. ,, ,, second swimming leg
3. ,, ,, fourth swimming leg.

B. MALE

The general body (Fig. IV, 12) of the male is more slender than that of the female. While in the former the first prosomal segment is only one-quarter time as wide as that of the second prosomal segment, in the latter it is one and a half times wider. The last prosomal segment in formalin preserved specimens is entirely concealed by the preceding segment. The urosome consists of six segments. The genital segment is very large, equivalent in length to the three following abdominal segments. But unlike in the female it is more or less of uniform width and bears on each side posteriorly three spines, two of them directed backwards and the third sidewards. The abdominal segments diminish slightly, both in width and length, towards the posterior side. The caudal ramus is wider than long and bears the same number of setae, with same proportionate lengths, as in the female. The size of the male is 1.0 mm.

Antennule (Fig. IV, 13) is geniculate on both sides. It is 12-segmented, with the first segment being the longest and seventh the shortest. The tenth segment is somewhat dilated, exhibiting near the end, in front, a short dentiform projection. Segments 3-10 bear each an aesthetask which is fairly long. The last segment also bears an aesthetask which is corresponding to that of the female. The proportionate lengths of the different segments are given below :

1	2	3	4	5	6	7	8	9	10	11	12	
21.6	5.5	13.1	4.5	4.5	4.0	2.5	5.2	4.2	15.7	6.0	13.2	= 100

The setae on the antennule of the male are longer compared to those of the antennule of the female. All other appendages including the fifth legs are identical to those of the female sex ; but they are relatively smaller.

Remarks—Nicholls (1944) has reviewed this genus and pointed out that it contains ten species including the four new species he added from the Australian waters. So far only one species has been reported from the Indian waters, *C. brevifurcatus*, recorded from Madras coast by Krishnaswamy (*loc. cit.*). The addition of the two present species brings the total number of known forms to twelve and shows that the genus probably is quite represented in our waters. The genus is very closely related to *Dyspontius* and the most reliable character by which they are distinguished is the armature of the first exopod : *Dyspontius* has only two outer spines on the end segment, whereas *Cryptopontius* has three. Wilson's definition (1932, p. 594) of the genus *Cryptopontius* as having the first prosomal segment longer than wide and third segment of first exopod with three spines and five setae, in contrast to *Dyspontius* which is said to have the first prosomal segment wider than long and the third segment of the first exopod with three spines and four setae is not correct, as is seen from a glance through the species described so far. All the species of the genus *Cryptopontius* are consistent in possessing three spines on the end segment of first exopod. The number of setae on that segment and the length-width ratio of the first prosomal segment, however, are not identical in all the species.

As far as the number of setae on the end segment of the first exopod is concerned, two types of situations are met with in the genus. There are five setae and three spines in the case of *C. brevifurcata* Giesb., *C. proximus* Nicholls, *C. similis* Nicholls, *C. gracilis* Wilson and *C. graciloides* sp. nov., while there are only four setae and three spines in the case of *C. longipes* Nicholls, *C. latus* Nicholls and *C. orientalis* sp. nov. I have not been able to go through the original descriptions of the four remaining species ; but the essential specific distinctions are available for the four remaining species, namely, *C. thorellii* Giesb., *C. capitalis* Giesb., *C. innominatus* Brady and *C. tenuis* Giesb. The first two species belong to the second group, namely, the group having four setae and three spines. Of the remaining two species, it is uncertain whether *innominatus* should be included at all in this genus. ' Brady's specimen was apparently damaged, but the urosome which he figures shows the genital segment of the same width throughout whereas it is characteristic of the genus that it should be very much widened anteriorly ' (Nicholls, *op. cit.* p. 25). Whether the number of setae in the case of *C. tenuis* is four or five could not be known ; presumably it is five as Wilson (*op. cit.*) has considered that number as the more normal for the genus. However, the fact becomes clear that the species of this genus are separable into two groups, namely, those having five setae in the third segment of the first exopod and those having only four setae on that segment.

C. graciloides is much related to *C. gracilis* but the differences between the two species are many : (i) in *C. gracilis* the first prosomal segment is as long as wide while here it is slightly wider than long ; (ii) in *C. gracilis* the abdominal segments decrease in width but increase in length posteriorly ; in *C. graciloides* the posteriormost segment is the longest and the middle segment the shortest ; in width, here also, they decrease posteriorly ; (iii) siphon is short and stout in *C. gracilis* ; the siphon is very long and slender in *C. graciloides* and (iv) size of the female 1.3 mm. in *C. graciloides* ; in *C. gracilis* the female measures only 1.0 mm. and the male 0.85 mm.

C. orientalis as noted earlier is close to *C. longipes* and *C. latus* in that in all these three species the terminal exopod segment of first legs carries three spines and four setae. *C. longipes*, however, is very easily distinguished from the other two species by the fact that in the former the first and second antennular segments are subequal and much longer than the third antennular segment while in both *C. latus* and *C. orientalis* the second antennular segment is much shorter than the first and third which are subequal. *C. orientalis* is identified from *C. latus* by the following differences : (1) Female of *C. orientalis* measures 1.05 mm. and male 1.0 mm. ; the female of *C. latus* is 1.30 mm. long. (2) The genital segment of *C. latus* is shown to be very wide, about three times wider than the following abdominal segment ; in *C. orientalis* the genital segment is about two and a half times wider than the next abdominal segment. At the junction of the wider proximal and narrower distal halves of the genital segment of *C. orientalis* there are two stout spines, on either side directed postero-laterally. In *C. latus* these spines are absent. (3) In *C. latus* the abdominal segments are more or less of equal dimensions, with the first segment a little longer than the other two segments. In *C. orientalis* the three abdominal segments diminish both in width and length to the posterior side. (4) The rudimentary exopod of the antenna is without any apical seta in *C. latus* while it is with one apical seta in *C. orientalis*. (5) The larger lobe of the maxillule carries one seta alone in *C. latus* and two apical and one basal setae in *C. orientalis*. (6) On the inner margin of the terminal segment of first endopod there is one seta present in the case of *C. orientalis* whereas there is no seta in that position in *C. latus*. (7) The rudimentary fifth leg in *C. latus* bears only a single apical seta while that of *C. orientalis* bears two apical setae.

Section **POECILOSTOMA**

Family CLAUSIDIIDAE EMBLETON

(Syn. HERSILIIDAE CANU)

Sars, 1913-1918, p. 144.

Genus *Hemicyclops* BOECK

Sars, 1913-18, p. 145.

Light and Hartman, 1937, p. 173.

Sewell, 1949, p. 65.

Gooding, 1960, p. 159.

Hemicyclops intermedius sp. nov.

Material examined—Two female specimens were obtained along with other weed washings from the Gulf of Mannar in July 1960. An additional single specimen was obtained from the same area in the following month. The type specimen is deposited in the Central Marine Fisheries Research Institute and bears the registered number J/575/8.

Description : A. FEMALE

This (Fig. VI, 1) is a fairly moderate-sized species with clearly marked prosome and urosome. The prosome is elongate-ovate and comprises the cephalothorax and three free metasomal segments. The cephalothorax is quite large, contains in it the widest part of the body and is longer than the other three prosomal segments combined. The latter gradually diminish in width to the posterior side and are subequal in length. The lateral margin of the third prosomal segment gives an articulated appearance. The posterior margin of the last prosomal segment is truncate in dorsal view. No rostral protuberance is visible dorsally. The urosome is 5-segmented and consists of the fifth leg-bearing segment, the genital segment and three abdominal segments. The first segment is small and rather six sided, each lateral margin being set apart into anter-olateral and postero-lateral divisions because of an expanded growth along the mid-transverse line. The fifth legs are borne on the postero-lateral margins. The genital segment is the largest and consists of an anterior wider half and a posterior narrower half which merge into each other without any trace of division between them. The abdominal segments decrease, both in length and breadth, to the posterior side. The combined length of the three abdominal segments is equal to that of the genital segment. The furcal rami are square and a little less long than the last urosomal segment. Each ramus bears five apical setae, one of which is very long, longer than the entire urosome, and one very short and subapical in position.

Antennule (Fig. VI, 2) is 7-segmented. Attachment of the basal segment to the cephalosome is at right angles to the plane of projection of the remainder of the appendage. In life the latter is held perpendicular to the main axis of the body. The relative lengths of the different antennular segments are as follows :

1	2	3	4	5	6	7		
13.8	10.6	11.2	22.4	15.2	13.4	13.4	=	100

The second segment is the shortest and the fourth the longest. The segments gradually diminish in their thickness to the distal tip. All the segments are provided with a number of setae, especially the second and third segments where there is a profusion of it. Many of the setae bear setules on their margins, several with setules on their tips alone. *Antenna* (Fig. VI, 3) is 4-segmented. It is twice bent on itself so that it looks like an inverted U-tube, with the first and the fourth segments forming the two limbs of unequal length and the middle two segments forming the base. The basal segment bears two setae on the proximal inner margin and a single seta on the distal outer corner. Three groups of ' comb rows ' of setae are found on this segment ; one row on the mid-inner margin and two rows on the outer margin, one each in the proximal and distal halves with some space left between the two rows. First segment is the longest. The second segment is almost as equal as the first. It bears on its outer margin at about the mid-length a stout seta which is ciliated on the outer margin. A ' comb row ' of setae is present on the outer margin between this seta and the base. The inner margin is uniformly ciliated. The third segment is peculiarly orientated ; its outer lateral margin is bent almost at right angle so that the proximal half of this bent side now becomes the outer lateral margin proper and the distal half becomes the apparent apical margin ; the original apical margin is displaced to the position of inner lateral margin ; the real inner lateral margin is highly reduced and constitutes the insignificant proximal

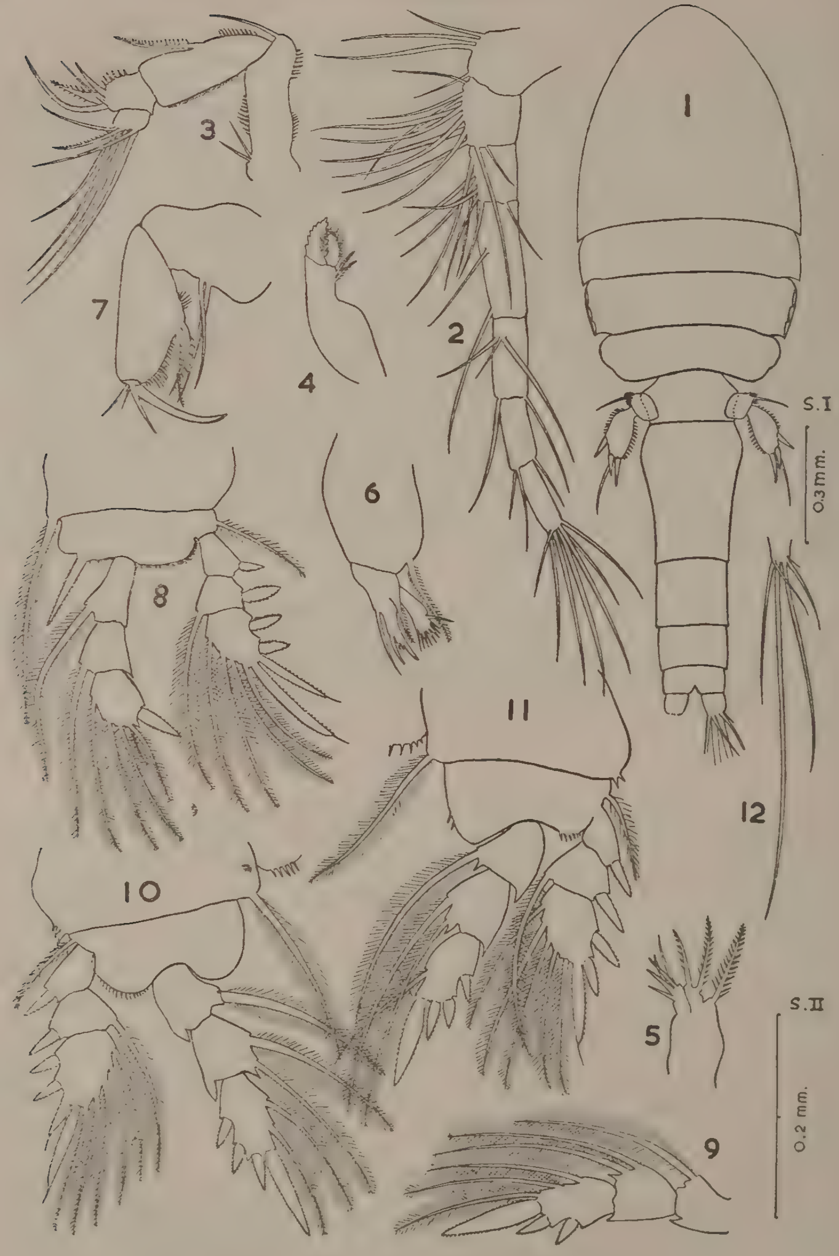

Figure VI, 1-12. *Hemicyclops intermedius* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, mandible.
5. ,, ,, maxillule.
6. ,, ,, maxilla.
7. Adult, female, maxilliped.
8. ,, ,, first swimming leg.
9. ,, ,, endopod of second swimming leg.
10. ,, ,, third swimming leg.
11. ,, ,, fourth swimming leg.
12. ,, ,, caudal ramus.

(First and twelfth diagrams drawn according to scale I and others to scale II) region of this side. The third segment bears two spines, two setae and a single group of ‘ comb row ’ of setae, all on the original outer lateral margin ; the ‘ comb row ’ is borne on the lateral half and the setae and spine on the apical half of this original outer lateral margin. The last segment of the antenna is the smallest with all the four sides clearly marked, held at right angle to the preceding segment and rather subrectangular and wider than long ; this segment bears on its apical margin seven setae four of which are long and characteristically curved, while the other three are short and slender ; one of these shorter setae is strongly ciliated on its inner margin.

All the four pairs of mouth appendages are present and they are closely compacted in typical poecilostome fashion. *Mandible* (Fig. VI, 4) is a small structure with the proximal half of its body proper much larger than the distal half ; the latter bears two ciliated setae on its outer (in natural position rather directed posteriorwards) distal margin ; the terminal armature consists of a foliaceous flap fringed all along its borders with cilia and a broad rather conical spine which is serrated on both margins. *Maxillule* (Fig. VI, 5) is only as large as the mandible and is clearly bilobed towards the distal side ; each lobe bears four setae, those on the inner appearing more like spines and much shorter ; three of the longer setae are ciliated. *Maxilla* (Fig. VI, 6) is bimerous ; basal segment much inflated, bearing on its distal inner face a stout solitary seta which is ciliated on both margins. The armature of the distal segment is quite complex ; in a lateral view the apex is Y-shaped with asymmetrical limbs and a thick body ; below this a seta is borne on each side, the one on the inner margin being ciliated and a little shorter than that on the outer margin ; on the inner face between the seta and the base of the segment is borne a subrectangular structure which is denticulated on the apical margin. *Maxilliped* (Fig. VI, 7) is probably the most conservative structure. It is trimerous, first two segments being subequal and large and the third highly reduced. The basal segment is armed with two long setae and the second with an inner prominence carrying two spinous setae. The terminal segment bears two claws of unequal lengths and two short setae.

All the four pairs of *swimming legs* (Fig. VI, 8, 9, 10 and 11) are biramous and with two segmented protopods. The rami are all trimerous but the exopod is invariably shorter. The setal formula of the swimming legs is as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	I	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	III	0	I	1	I	5	I	III
P_4	1	0	0	I	1	0	2	0	1	I	III	0	I	1	I	5	I	II

In the first leg the apical margin of the second protopod segment is uniformly ciliated. In the second and third legs the first protopod segment bears a group of three spinules on its outer distal margin and the second protopod segment, on its face between the exopod and endopod, a ‘ comb row ’ of spinules. In the fourth leg spinules on the first protopod segment are reduced to two ; the second protopod segment bears, besides the ' comb row ', two small spinules on its inner distal face. *Fifth leg* is 2-segmented and inserted on the ventro-lateral face of the first urosomal segment, one on each side. The proximal segment bears a single seta externally and is armed at the distal external angle with a row of fine spinules. The second is typical of the genus and more than twice as long as the first segment ; it is much narrower at the base and is provided with spinules on both the outer and inner margins. It bears three rather conical broad based spines and a delicate seta between the second and third spines ; the latter two spines may be termed apical in position while the first spine is sub-apical on the outer side.

B. MALE

Unknown.

Remarks—Light and Hartman (1937) reviewed this genus and considered the following species as valid :

1. *H. pugettensis* Light and Hartman, 1937.
2. *H. aberdonensis* (Scott & Scott), 1892.
3. *H. adhaerens* (Williams), 1907.
4. *H. callianassae* Wilson, 1935.
5. *H. purpureus* Boeck, 1873.
6. *H. thysonotus*, Wilson, 1935. and
7. *H. americanus* Wilson, 1932.

H. elongatus Wilson, 1937 was described in the same year as Light and Hartman's review and so was not included in their list. All these species were reported to occur along the American coasts except *H. aberdonensis* which was recorded only from Scottish seas. Gooding (*loc. cit.*) provided an excellent review of the American species of this genus and considered *H. pugettensis* and *H. callianassae* to be synonymous with *H. thysonotus* ; and *H. americanus* as a synonym of *H. adhaerens*. He added two new species *H. arenicola* Gooding and *H. subadhaerens* Gooding to bring the total number of known American species again to six. *H. purpureus* has, however, been omitted from his key for he is not sure whether Wilson's identification of this species from the Canadian waters is correct in view of 'Wilson's lapses in descriptions of other species in this genus '.

The report of the occurrence of the species of this genus in other parts of the world is rather scanty. Besides the two American species referred to above. I am aware of the following species having been reported as belonging to this genus after Light and Hartman's review :

1. *H. leggi* (Thomp. & Scott), 1903	Both from Ceylon ; transferred to this genus as suggested by Sewell, 1949
2. *H. tamilensis* (,,), ,,	
3. *H. australis* Nicholls, 1944	Australia
4. *H. indicus* Sewell, 1949	Nicobar Islands
5. *H. visendus*, Humes, Cressey and Gooding, 1958	Madagascar
6. *H. bacescui* (Serban) 1956	Mediterrannean
7. *H. dilatatus* Shen and Bai, 1956	China

H. thompsoni Canu was kept in abeyance by Light and Hartman from the genus *Hemicyclops* because that species was based upon two immature females found on the body of *Callianassa subterrannea* Montagu. However both Stock (1959) and Humes, Cressey and Gooding (1958) have recognised this as a species of *Hemicyclops*. There are, therefore, fifteen species including the one described in this paper known in the genus *Hemicyclops*.

Gooding (*loc. cit.*) has pointed that four of the American species namely, *adhaerens*, *subadhaerens*, *arenicolae* and *elongatus* fall into a distinct group, more or less constituting a superspecies. ' This superspecies would be characterised mainly by the separation between genital and first abdominal segments and the well-developed sixth legs in the adult females ; the reduced mandibular setation and presence only of simple terminal elements on the maxilla and of setulose exopod spines on all the swimming legs in both sexes ; and the attenuated ' scaly ' tip of the male maxilliped ' (p. 164). To this superspecies—complex should probably be added *H. tamilensis* for in this species also the genital and the first abdominal segments are completely free. However, we have no information about the various appendages which are of systematic importance. *H. indicus* and *H. dilatatus* are separated from others easily by the subquadrate nature of the genital segment which is followed by three abdominal segments. In *H. leggi* only the male is known and the possibility or otherwise that the present example represents the unknown female of that species is discussed later (*vide infra*).

In the remaining seven species the genital segment is quite elongate with a broader anterior and a narrower posterior regions and there are three post-genital segments. However, in *bacescui*, *visendus*, *thompsoni* and *thysonotus* the caudal ramus is distinctly long, always more than twice as long as wide and are easily distinguished from *purpureus*, *australis* and the present species, all of which have their caudal rami sub-quadrate.

H. intermedius sp. nov. is not referred to *H. purpureus* because of the following differences :

H. intermedius	*H. purpureus*
1. The exopod of first leg has four setae and four spines.	The exopod of first leg has two spines and six setae.
2. Relative lengths of the antennular segments : 13.8 ; 10.6 ; 11.2 ; 22.4 ; 15.2 ; 13.4 ; 13.4=100	Relative lengths of the antennular segments : 10.0 ; 23.2 ; 9.4 ; 18.8 ; 13.5 ; 14.1 ; 11.0=100
3. The antennal segments are bent twice forming an inverted ' U '-tube.	The first segment is bent at right angles to the next three segments which are linear.
4. Caudal ramus as long as wide.	Caudal ramus slightly longer than wide.
5. The basal segment of maxilla with one seta. The distal segment as described.	Basal segment of maxilla with two setae. The distal segment simpler in structure.
6. Terminal segment of maxilliped bears limited number of setae and spines.	Terminal maxilliped segment bears four setae and two spines.
7. Length of female 1.9 mm.	Length of female 1.15 mm.

The present species is related to *H. australis* but the following differences are noticeable between the two species :

	H. australis	*H. intermedius*
1.	Size : 1.38—1.40 mm.	1.9 mm.
2.	Prosome : Urosome=53 : 47	Prosome : Urosome=51 : 49
3.	Proximal half of genital segment more than one and a half times wider than the distal half.	Proximal half of genital segment only a little wider than the distal half.
4.	The genital segment longer than the three abdominal segments combined.	The genital segment only as long as the three abdominal segments combined.
5.	Caudal ramus longer than the last abdominal segment.	Caudal ramus not as long as the last abdominal segment.
6.	Third antennular segment much shorter than the second.	Third antennular segment as long as the second.
7.	In the mandible, the body proper bears a single seta on its distal inner margin.	In the mandible the body proper bears two setae on its distal inner margin.
8.	In the first leg the terminal exopod segment carries six setae and two spines.	In the first leg the terminal exopod segment carries four setae and four spines.

H. leggi was created by Thompson & Scott (*loc. cit.*) from the Ceylon side of the Gulf of Mannar and was referred to the genus *Hersiliodes* Canu. Sewell (*loc. cit.*) suggested its removal to the genus *Hemicyclops*. The single male specimen which they obtained from sponge washings measured only 1.5 mm. Taking into consideration this size difference of the male of *H. leggi* and the female of *H. intermedius* as well as the same area of the distribution (hardly 50 miles apart) of the two species, one is tempted to suggest that they represent the male and the female of the same species. However a number of difficulties come in the way. Although the male is generally smaller in size than the female in many of the species of the genus, this condition is never the rule, for in *H. visendus* it is clearly larger than the female : the male measures 2.06 mm. while the female is only 1.87 mm. long. However, in this genus the male is known to differ from the female only in the structure of the maxilliped and the urosome. The differences observed in other structural details are considered of specific importance. Such characters are listed below :

(*a*) The proportionate lengths of the antennular segments are distinctly different in the two species.

	1	2	3	4	5	6	7	
H. leggi	13.0	16.0	8.5	23.0	15.0	10.5	14.0	= 100
H. intermedius	14.5	10.6	10.7	22.0	15.5	13.35	13.35	= 100

(*b*) First segment of the antenna in *H. leggi* is bent at right angles to the remainder of the appendage ; in *H. intermedius* the antenna is bent twice on itself forming an inverted U-tube with the first and the last segments forming the two limbs and the middle segments forming the base. Further the setation of the constituent segments is also different in the two species.

(*c*) In the maxilla of *H. intermedius* the basal segment bears only a single seta on its distal inner margin, while two distinct setae are borne in *H. leggi* ; further the segment itself is very short in *H. leggi.*

(*d*) The terminal endopod segment of first leg bears five setae and one spine in the present species whereas for *H. leggi* it is shown to be only four setae and one spine.

(*e*) The length-breadth ratio of the fifth leg in *H. leggi* is 3 : 2 while it is 2 : 1 in *H. intermedius.* Since Thompson & Scott (*loc. cit.*) themselves have pointed that their species ' is easily recognized from any other members of the genus by the proportionate lengths of the joints of the anterior antennae and by the quadrangular fifth leg ', I consider the present form as a new species.

Family LICHOMOLGIDAE SARS

Sars, 1918, p. 149.

Sub-family LICHOMOLGINAE GURNEY

Gurney, 1927, p. 463.

Genus *Pseudoanthessius* Canu

Canu, 1889, p. 344.

Sars, 1918, p. 166.

Pseudoanthessius agilis sp. nov.

Material examined—Numerous males and females of this copepod were captured from the sponge washings from the Gulf of Mannar in July and August 1960. On one occasion it was obtained from general invertebrate and weed washings (which of course included sponges). The holotype, allotype, and paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J 576/9, J 577/9, and J 578/9 respectively.

Description : A. FEMALE

Colour is monotonously whitish opaque ; but the edges of the different segments possess a beautiful tinge of violet which appears to be due to the deposit of calcium. *The body* (Fig. VII, 1) is very graceful in appearance, quite symmetrical and almost cylindrical. The prosome consists of four segments and the urosome of five segments. The first prosomal segment is, however, partially divided into the cephalosome and the first leg-bearing segment. The cephalothorax is the widest part of the body, being almost three times wider than the last prosomal segment. In length the cephalothorax is twice as long as that of the three following segments combined. The matasomal segments gradually diminish in width posteriorly. All the segments excepting the last prosomal segment are provided with epimeral plates. There is a clear rostral prominence on the anterior margin of the first prosomal segment. In the urosome the first segment bears the fifth pair of legs which are typically reduced. The genital segment forms a major part : it is much longer and wider than the other segments joined together and carries on each side a small spine on

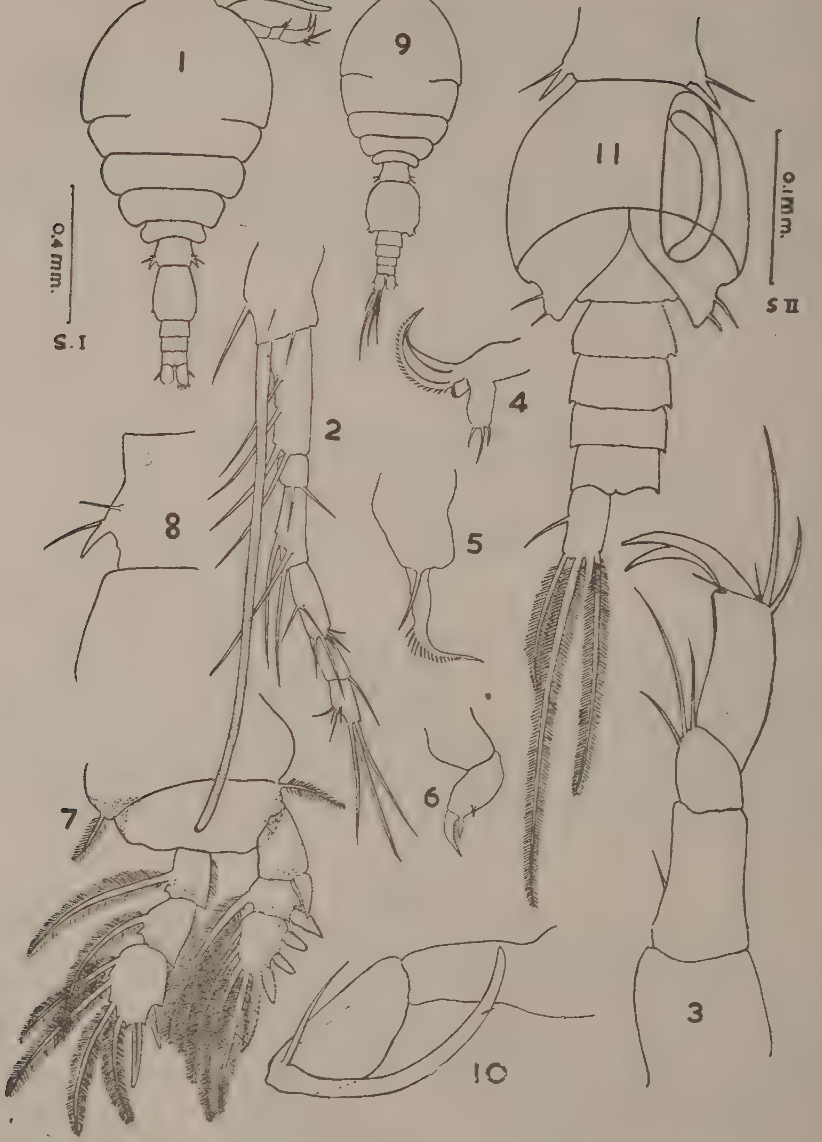

Figure VII, 1-11. *Pseudoanthessius agilis* sp. nov.

1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, ,, antenna.
4. ,, ,, maxillule and mandible.
5. ,, ,, maxilla.
6. ,, ,, maxilliped.
7. Adult, female first swimming leg.
8. ,, ,, fifth leg with parts of urosome.
9. ,, male, dorsal view.
10. ,, ,, maxilliped.
11. ,, ,, urosome.

(First and ninth diagrams are drawn to scale I and others to scale II) its postero-lateral margin. First, second and third abdominal segments are subequal in length but diminish in width posteriorly. Caudal rami are parallel, distinctly exceeding the last abdominal segment in length and a little less than twice as long as wide. Each of them bears four terminal setae and a small spine on the outer margin at its mid-length.

Antennule (Fig. VII, 2) is moderately long, reaching when extended posteriorly to the end of the cephalosome. It is 7-segmented and the segments have the following relative lengths :

1	2	3	4	5	6	7	
19.6	24.8	6.0	15.7	13.9	10.0	10.0	= 100

The second segment is the largest and the third the shortest. Fourth and fifth segments are approximately of equal length : so also are the last two segments. The first segment is fairly stout and long and bears an aesthetask equal in length to that of the entire antennule. All the segments are provided with a number of setae. The antenna is well-developed and consists of four segments. First segment is devoid of any seta. The third segment bears three setae, of unequal length on its inner anterior distal margin. The last segment bears four setae of varying lengths and two stout spines ; the latter are characteristically bent to the anterior side. The *mandible* (Fig. VII, 4) as usual, is a flat blade, produced into an elongate, tapering tip which curves outwards. The entire inner margin is lined by minute spinules. A broad, rather rectangular, chitinized flap is present near the inner base of the blade. It is tipped with fine spinules. The base of the mandible is closely associated with the base of the maxillule and are mounted on the same skeletal frame work. *Maxillule* (Fig. VII, 4) is simple, rather rectangular in shape, bearing three spines of unequal length on the apical margin. In the *maxilla* (Fig. VII, 5) the basal segment is quite pronounced and bears a seta besides the apical lash ; the latter is moderately long, bent at about right angles in the distal part and bearing along its entire length slender spinules which diminish in length distalwards. The *maxilliped* (Fig. VII, 6) consists of two segments, the basal is the wider, but the distal is the longer ; the latter bears two serrated spines at the apex and a small spinule at about two-third length. Maxilliped is rather feeble.

The *swimming feet* (Fig. VII, 7 ; Fig. VIII, 1, 2 and 3) are biramous, the ramus being three-segmented, except in the case of the endopod of the fourth leg which is only one-segmented. The legs are notable in that the corners and edges of the various segments are highly calcified and have a dark violet tinge. The setal formula of the swimming legs are as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	0	0	0	1			II					0	I	1	I	5	I	II

First leg is the smallest. Second and third legs are similar except for the differences in the setation of the terminal segment of the endopod. In the fourth leg the reduced endopod is half as long as the exopod and its margins are entire. The fifth pair of legs, as in other species of the genus, are replaced on each side by a spine inserted directly to the postero-lateral margin of the first urosomal segment and accompanied by two small setae ; the spine is smooth, exhibiting at the base a slight dilation and is directed posteriorwards. One of the setae arises just close to the spine and the other a little upwards. The size of the female is 1.18 mm.

B. MALE

The male (Fig. VII, 9) is much smaller than the female, displaying the usual sexual differences. The prosome is more oval and compact than in the female and the first and the second prosomal segments only partly fused. The *urosome* (Fig. VII, 11) is 6-segmented. The genital segment is very much widened, almost as wide as long and uniform throughout the length. At the postero-lateral corners the segment becomes constricted to a bud-like structure, each of which bears two fine spines. The four abdominal segments diminish both in length and width to the posterior side. The caudal rami and setae are similar to those of the female. The *maxilliped* (Fig. VII, 10) is very large and prehensile, many times longer than the corresponding structure of the female. It consists, however, of the same two segments which are subequal in length. The terminal spine of the second segment is extremely large, characteristically bent inward and bears a small spine on its distal posterior margin. There is also a seta close to the base of the terminal spine. The mouth parts as well as other remaining appendages are identical to those of the female.

Remarks—A number of species that were originally attributed to this genus have been recorded from Indian waters but several of these have subsequently been transferred to other genera.

Nicholls (*loc. cit.*) provided an excellent key to the genus and enlisted the following species as known to the time of his writing :

1. *P. liber*, (Brady & Robertson), 1875.
2. *P. assimilis* Sars, 1917.
3. *P. sauvagei* Canu, 1891.
4. *P. obscurus* A. Scott, 1909.
5. *P. mucronatus*, Gurney, 1927.
6. *P. tenuis* Nicholls, 1944.
7. *P. gracilis* Claus, 1889.
8. *P. weberi* A. Scott, 1909.
9. *P. nemertophilus* Gallien, 1935.
10. *P. thorelli* (Brady & Robertson), 1875.
11. *P. dubius* Sars, 1918.
12. *P. concinnus* Thompson & Scott, 1903.

Illg (1950) revised the key incorporating three more species, *P. spinifer* Lindberg, 1946, *P. graciloides* Sewell, 1949 and *P. latus* Illg, 1950 that have since then been added. The present species brings the total number of known numbers of this genus to sixteen. The species of this genus are divisible into two groups : those in which the outer margin of the fourth endopod is entire or is simply convex : and those in which the outer margin of the fourth endopod is broken by a swelling or indentation which may become a conspicuous knob or notch. *P. spinifer*. *P. liber*. *P. assimilis* and the present species fall under the first group. *P. spinifer*. however. is easily separated by the fact that the lateral margins of the genital segment of this species are produced into conspicuous expansions. The distinctions between *P. liber* and *P. assimilis* on the one hand and *P. agilis* sp. nov. on the other are many. and the most important of them consists of : (*a*) the general shape of the body ; (*b*) the nature of the fusion of the first and second prosomal segments ; (*c*) the proportionate lengths of the segments of the antennule : (*d*) the proportionate lengths of the segments and the size of the terminal spines of the antenna : and (*e*) the number of setae borne on the inner margin of the third segment of the third leg. The differences between *P. liber* and *P. assimilis* have already been pointed out by Nicholls and consists chiefly the length-width relationship of the caudal rami and in the general form of the body.

Genus *Macrochiron* BRADY

Brady, 1872, p. 433.

Sars, 1913-18, p. 163.

Subgenus *Macrochiron* SEWELL

Sewell, 1949, p. 99.

Macrochiron (*Macrochiron*) *rigida* sp. nov.

Material examined—Eight females and three males were obtained from the general weed and invertebrate washings mainly sponges from the Gulf of Mannar. The holotype. allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and bear the registered numbers J 616/10, J 617/10 and J 618/10 respectively.

Description : A. FEMALE

The body (Fig. IX. 6) is moderately slender and cylindrical with the prosome not much dilated. being regularly oblong-oval in outline and rather strongly vaulted dorsally. The prosome is 4-segmented and the urosome 5-segmented. The first prosomal segment constitutes the major part of the body being only a little less than equal in length to the entire remainder of the body ; it is also the widest of all segments. Second. third and fourth segments diminish in width posteriorwards. Of these. second is the longest and third the shortest. The first urosomal segment is moderately large and bears the fifth pair of legs. The genital segment is the largest urosomal segment. being distinctly wider and longer than the combined length of the three abdominal segments. The caudal ramus is as long as the last abdominal segment and is slightly longer than broad. Each ramus bears six setae, two of them being slender, looking more like spines.

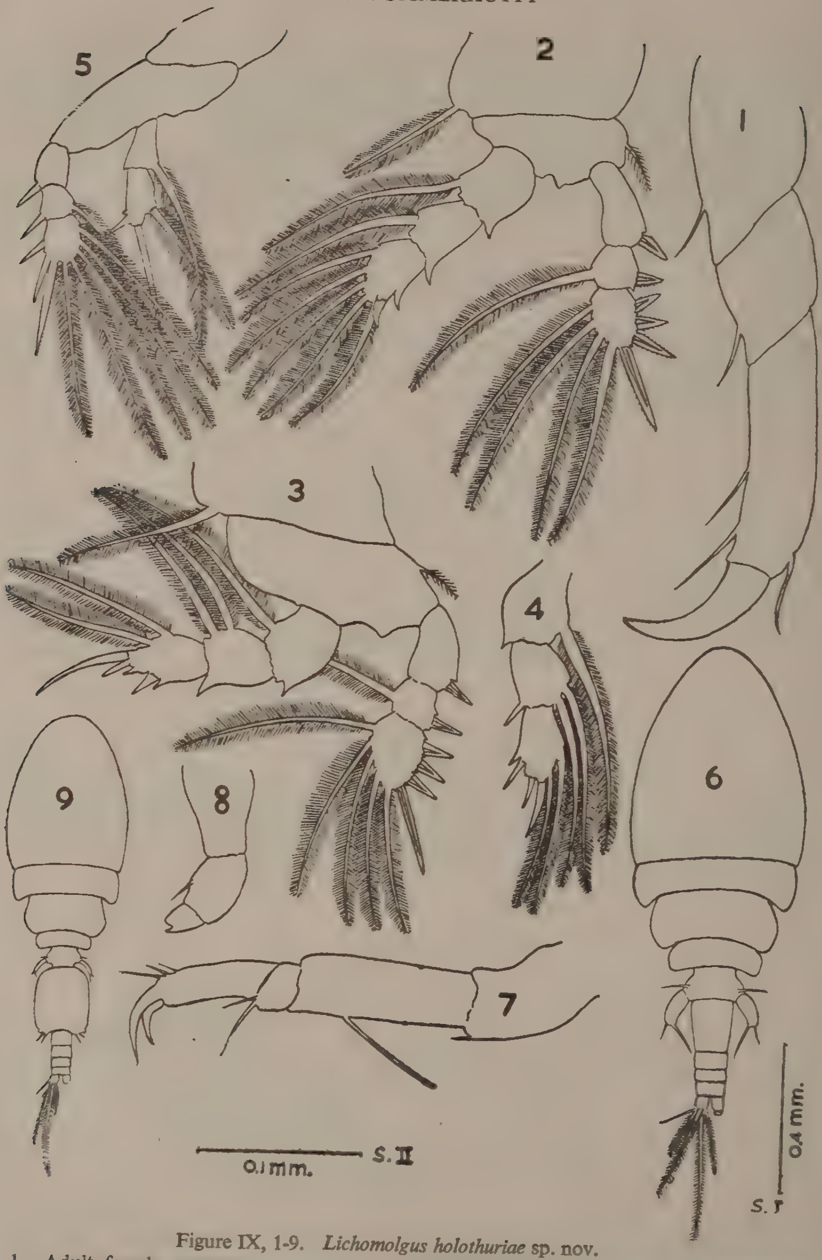

Figure IX, 1-9. *Lichomolgus holothuriae* sp. nov.

1. Adult, female antenna.
2. ,, ,, first swimming leg.
3. ,, ,, second swimming leg.
4. Adult, female, endopod of third swimming leg.
5. ,, ,, fourth swimming leg.

Macrochiron (*Macrochiron*) *rigida* sp. nov.

6. Adult female, dorsal view.
7. ,, ,, antenna.
8. Adult, female, maxilliped.
9. ,, male, dorsal view.

(Sixth and ninth diagrams drawn according to scale I and others according to scale II)

Antennule (Fig. X. 1) is 7-segmented, and rather not very long. Second segment is the largest and last the shortest. All the segments are provided with a number of setae : first segment also carries a small finger-shaped structure on its anterior distal corner ; two fairly long aesthetasks are borne, one each by the fifth and seventh segments. The proportionate lengths of the antennular segments are given below :

1	2	3	4	5	6	7	
14.6	22.7	9.6	18.3	14.6	11.7	8.5	= 100

Antenna (Fig. IX. 7) is comparatively short and consists, as usual, of four segments. Second segment is the largest and third the shortest while the first and the last are subequal in between these two extreme situations. Although the second segment of the antenna in this genus usually bears a spine, in the present case it is found to be a sensory filament rather than a spine. Other cephalosomal appendages are quite normal.

The four pairs of *swimming legs* (X. 3, 4, 5 & 6) are biramous, each ramus being 3-segmented, except the fourth endopod which is 2-segmented. First to third legs are more or less of equal size while the fourth is distinctly smaller ; in the latter, although the endopod is only 2-segmented, it is only a little less than the length of the exopod. The setal formula of the four pairs of the swimming legs are given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P$_1$	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	3	1+I	III
P$_2$	1	0	0	0	1	0	2	0	3	II	I	0	I	1	I	5	I	III
P$_3$	1	0	0	0	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P$_4$	0	0	0	I	1	0	II					0	I	1	I	5	I	III

Fifth leg is cylindrical and fairly large, reaching more than half the lengths of the genital segment. The basal segment, as usual, is fused, with the first urosomal segment and each bears a solitary seta at its distal outer corner. The distal segment is slightly curved inwards and bears two terminal setae of unequal length. The size of the female is 1.25 mm.

B. MALE

The male (Fig. IX, 9) is much smaller than the female but retain the general form of the female. The prosome is greatly identical in both shape and proportionate lengths of different segments. The urosome is 6-segmented, consisting of the fifth leg-bearing segment, the genital segment and four abdominal segments. Of these, the first segment is comparable to that of the female and bears the fifth legs which are much reduced in size. The genital segment is greatly enlarged both in length and width. It is almost equivalent to the combined length of the other

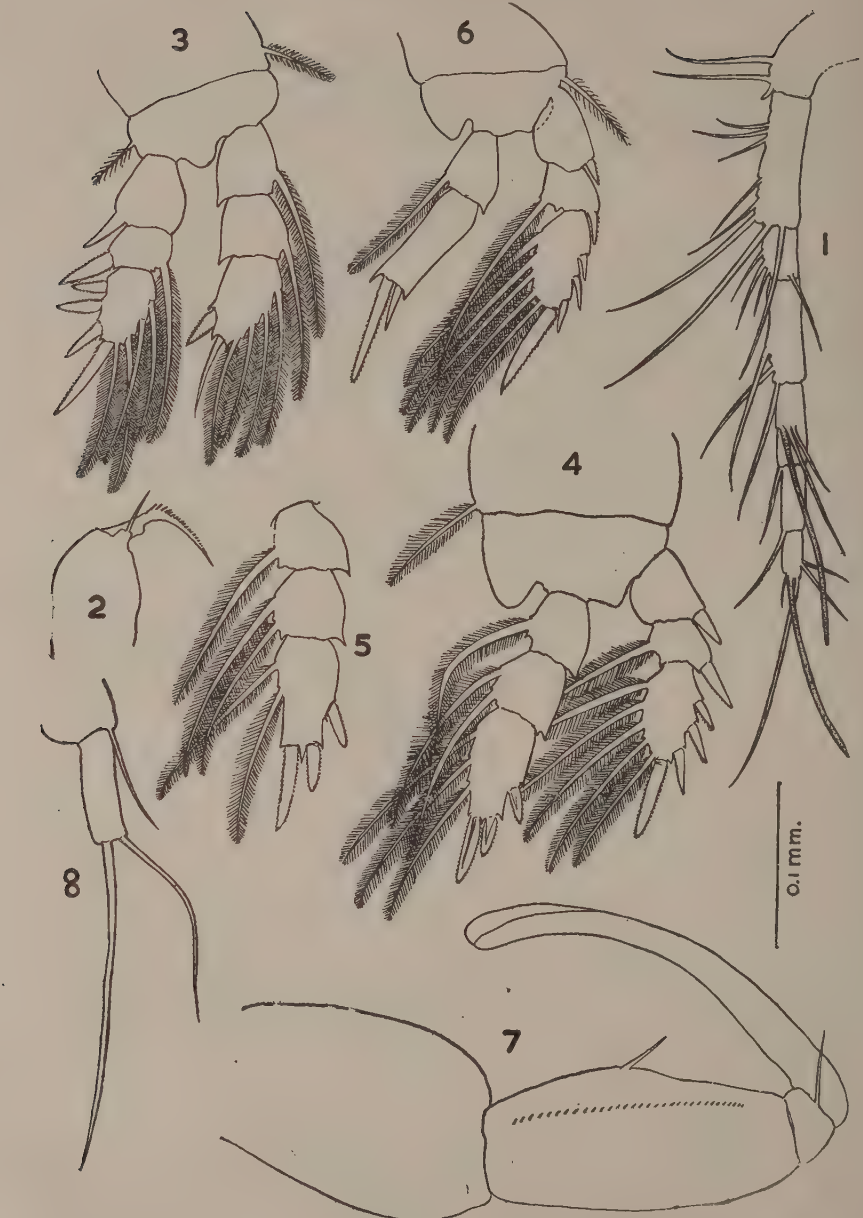

Figure X, 1-8. *Macrochiron* (*Macrochiron*) *rigida* sp. nov.

1. Adult, female, antenna.
2. ,, ,, maxilla.
3. ,, ,, first swimming leg.
4. Adult, female, second swimming leg.
5. ,, ,, endopod of third swimming leg.
6. ,, ,, fourth swimming leg.

Lichomolgus brevifurcata sp. nov.

7. Adult, male, maxilliped.
8. Adult, female, fifth leg.

urosomal segments ; at its posterior margin it bears, on either side, a pair of spines which are directed postero-laterally. The abdominal segments diminish both in length and width to the posterior side. The length of the male is 1.0 mm. The *maxilliped* is quite large, similar to that of the related species and exhibiting sexual dimorphism. The fifth legs are much smaller in size and are also slender although in essential features they are similar to those of the female. The two segments of the fifth leg bear the same number of setae as in the female.

Remarks : Sewell (*loc. cit.*) has split the genus *Macrochiron* Brady into two subgenera, *Macrochiron* (*Macrochiron*) to receive all those species in which the endopod of the fourth leg is composed of two segments, as in the case of the type species, *M. fucicolum* Brady and *Macrochiron* (*Paramacrochiron*) to include those species in which the fourth endopod is only 1-segmented. He attributed the following species to the subgenus *Macrochiron* (*Macrochiron*) Sewell.

1. *M.* (*Macrochiron*) *fucicolum* Brady.
2. *M.* ,, *hirsutipes* (T. Scott).
3. *M.* ,, *alabatensis* (Kossman) (=*Lichomolgus alabatensis*)
4. *M.* ,, *simplex* (Thom. & Scott) (=*L. simplex*)
5. *M.* ,, *buddhensis* (,,) (=*Lichomolgus buddhensis*)
6. *M.* ,, *robustus* (,,) (= *L. robustus*)
7. *M.* ,, *gracilipes* (A. Scott) (= *L. gracilipes*)
8. *M.* ,, *congoensis* (T. Scott) (= *L. congoensis*)
9. *M.* ,, *longipes* Sewell
10. *M.* ,, *spinipes* Sewell

The present species does not correspond to any of the known forms and therefore is treated here as a new species. *M.* (*Macrochiron*) *rigida* may be defined as follows : (1) Length of the female 1.25 mm. ; length of the male 1.0 mm. (2) the cephalosome and first pedigerous segment are fused and the combined cephalothorax is only a little less long than the entire rest of the body. (3) The posterior half of the cephalothorax is the widest part of the body. (4) The genital segment in the female is vase-like, the proximal wider part gradually but slightly diminishing in width to the posterior side ; it is distinctly longer and wider than the three abdominal segments together. In the male the genital segment is rather rectangular with parallel sides ; it is almost as long as the entire remainder of the urosome ; there is a pair of postero-laterally directed spines on either of its posterior margins. (5) Caudal ramus as long as the last abdominal segment and is longer than wide. (6) The proportionate lengths of the antennular segments and the setal formula of the swimming legs are as given in the text. (7) The fifth pair of legs stout, incurved, rather cylindrical and wider in the proximal half ; the male fifth legs are highly reduced.

Recently Stock (1957) expressed the opinion that the name *Macrochiron* should be used at generic level for the conception of a limited number of species all agreeing in the possession of a complexly built 3-segmented posterior antenna. According to him, all other species that have been referred to this genus but in which there is a normally built 4-segmented posterior antenna should be removed to the genus *Lichomolgus* or other related genera. Those transferred to *Lichomolgus* differ, however, from the typical members of the genus in a number of characters : (1) The mandibles have the lappet conspicuously dilated at the base. Its armature consists not only of spinules lining the margin but also of crest-like ridges, denticulations, etc.

(2) The maxillipeds of the female are well-developed, three-segmented, with at least two setae on the second segment and a cheliform structure on the third segment. (3) The third exopod segment of the fourth leg has usually three outer spines, though some species have two outer spines.

To accommodate this rather natural group of uncertain systematic status within the genus *Lichomolgus*, Stock (1959) proposed to erect a new subgenus, but left it unnamed, 'since no name is available at the moment for the subgenus and since some species tend to be intermediate. . .'.

If Stock's suggestions are accepted and *Macrochiron* is redefined as proposed by him, then the present species should be transferred to *Lichomolgus* and placed under the subgenus proposed by him.

Genus *Lichomolgus* THORELL

Canu, 1892, p. 227

Sars, 1918, p. 150

Sewell, 1949, p. 96

Lichomolgus holothuriae sp. nov.

Material examined—Numerous females and a few males were obtained from the holothurian washings of the Gulf of Mannar. They live inside the body cavity of the holothurians and are obtained by keeping the host in seawater to which menthol is added. The copepods are brought out by vigorously shaking the host after the interval of an hour or so. In colour they are dull whitish approaching to a pale yellow. The holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and have the registered numbers J 628/11, J 629/11 and J 630/11 respectively.

Description : A. FEMALE

The body (Fig. VIII, 4) is highly depressed, flattened and more or less oval in outline. The prosome consists of four segments. The first prosomal segment is eminently large, only a little less than the combined length of the rest of the body. Its posterior corners end in angular edges. There is no trace of division between cephalosome and first leg-bearing segment. Second and third segments are moderately large but much smaller than the first prosomal segment. They are provided with epimeral plates and have angular posterior edges. The last prosomal segment is quite small, less than one-third of the width of the prosomal segment and about one-ninth of the latter's length. It is partly hidden by the preceding segment. The four prosomal segments bear the four pairs of swimming legs. The urosome is 5-segmented, consisting of the fifth leg-bearing segment, the genital segment and three abdominal segments. The first two segments are very large, subequal each distinctly longer than the combined lengths of the three abdominal segments. In width the genital segment exceeds all other segments of the urosome. It bears a pair of spines on either of its postero-lateral margins; one of the spines is much larger than the other and is borne on a protrusion. The caudal rami are very short,

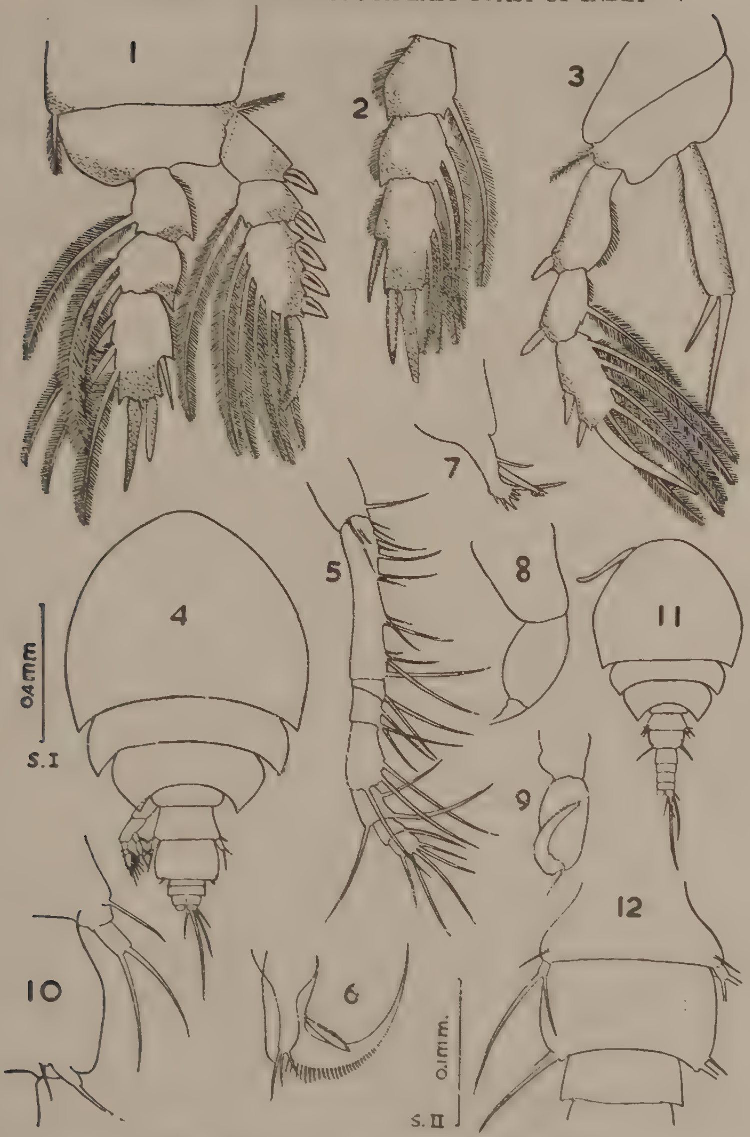

Figure VIII, 1-12. *Pseudoanthessius agilis* sp. nov.

1. Adult, female, second swimming leg.
2. ,, ,, endopod of third swimming leg.
3. Adult, female, fourth swimming leg.

Lichomolgus holothuriae sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, mandible and maxillule.
7. ,, ,, maxilla.
8. ,, ,, maxilliped.
9. Adult, male, maxilliped.
10. ,, female, fifth leg with parts of urosome.
11. ,, male, dorsal view.
12. ,, ,, fifth leg with parts of urosome.

(Fourth and eleventh diagrams are drawn according to scale I and others according to scale II) stumpy, much wider than long, the length-width ratio being 5 : 3. Each of the rami bears five setae, one of which is clearly long, almost equivalent to the urosome.

Antennule (Fig. VIII, 5) is 8-segmented, typically of the lichomolgid type with the second segment being the largest and third the shortest. First and fifth segments are fairly large but each of them is less than half the length of the second segment. While the fourth and fifth segments are longer than wide, the reverse is true of the last two segments. All the segments are provided with a number of setae, some of them appearing more like spines. The antennule does not bear any aesthetask. The relative lengths of the various segments are as follows :

1	2	3	4	5	6	7	8	
13.0	40.2	2.6	7.4	17.0	8.9	5.3	5.6	= 100.

Antenna (Fig. IX, 1) is very large in size compared to the antennule. While the latter hardly reaches the middle of the first prosomal segment and is fragile, the antenna is stoutly built and extends to more than three-fourth the length of that segment. However, it is only three-segmented. The first two segments are subequal, while the third is quite large and almost as large as the former two combined. The two segments bear a seta each. The third segment bears three setae and a stout terminal spine which is half the length of the segment itself. The spine is incurved like a beak. The *mandible* (Fig. VIII, 6) is distinct from the maxillule and juxtaposed to it. It consists of a blade with its anterior (outer) margin lined by fine long spinules which decrease in length distalwards. At the base of the posterior (inner) margin of this blade, there is an oblique ridge with fine cilia on one of its margins. The blade is produced into a flagellum. The *maxillule* (Fig. VIII, 6) is rather small, elongated and bearing terminally three spines. The *maxilla* (Fig. VIII, 7) is rigid. It has two separate spines besides the terminal lash which is denticulated ; while the proximal spine is simple, the distal one is stout and has its tip provided with small denticles ; the distal part of the apical lash is much slender than in all other known species and is rather straight, being ciliated on the inner margin. The basal part of the lash is distinct and is provided with stout but small spinules instead of the usual setae. *Maxilliped* (Fig. VIII, 8) is simple and small. It consists of two segments of approximately equal length and width. The distal segment bears a seta and a terminal claw which is conical and rather small.

The first three pairs of *swimming legs* (Fig. IX, 2, 3, 4 & 5) are biramous, each ramus being trimerous. The legs are approximately of equal size but differs in setation. In all the legs, while the exopod is orientated in the same axis as the protopod, the endopod is borne at an angle ; in the case of third legs exactly at right angles to the protopod. The fourth leg is biramous. The exopod is 3-segmented ; the endopod is only 2-segmented. The fourth leg is much smaller than the other legs. The setal formula of the swimming legs are as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	1	0	0	1	1	0	2	0	2	II	I	0	I	1	I	4	1+I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	4	1+I	III
P_4	0	0	0	0	1	0	—	—	—	—	—	0	I	1	I	4	1+I	II
								1		II								

Fifth leg (Fig. VIII. 10) is 2-segmented, the basal segment being fused with the first urosomal segment and bearing a single seta ; the second segment is well defined and fairly large ; it bears two terminal setae of unequal size. The size of the female is 1.2 mm.

B. MALE

The male (Fig. VIII. 11) is much smaller than the female measuring only 0.75 mm. The prosome is very similar to that of female except in size. The urosome is composed of six segments. The first two segments are subequal in length and width. The second segment bears on each of its postero-lateral corners a fairly long spine which is said to be the remains of the sixth pair of legs. The four abdominal segments are much narrower and form a cylinder ; of these, the third to fifth segments are more or less of equal dimensions while the second abdominal segment is distinctly longer and wider. All the appendages are similar to those of the female except the *maxilliped* (Fig. VIII. 9) which is very peculiar. In the males of the lichomolgids the maxilliped is generally well developed being many times larger than that of the female. It is supposed to have a geniculate function. In the present species the male maxilliped exhibits some differences in the structure from that of the female but is hardly larger. In both cases it is 2-segmented. In the female the two segments are sub-equal and the terminal spine of the second segment is very small. In the male, however, the second segment is larger and the terminal spine of that segment is quite large. Further the outer margin of the spine is partly serrated.

Lichomolgus serratipes sp. nov.

Material examined. Eighteen female specimens were obtained from washings of the seapen *Pteroides esperi* Herklots ; the specimens were given to me by Dr. S. Jones. Some of these were carrying egg-sacs which were asymmetrical and which appeared to have started hatching. The left egg sac is always longer and contains a larger number of eggs than the right one. The holotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and bear the registered numbers J 658/12 and J 659/12 respectively.

Description :

A. FEMALE

The animal (Fig. XIII. 5) is very robust and rather elongate-oval. The prosome is very conspicuous, constituting as it does, more than four-fifth of the length of the body. It consists of four segments : The first segment is quite large, equal in length to the entire remainder of the body. This segment is considerably expanded and much broader than the succeeding ones ; its posterior margin is concave so that the postero-lateral corners constitute acute angles. The second segment is distinctly less wide than the first one and is crescent-like with arms directed backwards. The third segment is less broad than the preceding one but exceeds the latter in length, the medial line being the longest part. The postero-lateral margins of this segment are finely serrated. The fourth segment is very small, a little wider than the genital segment and completely hidden by the preceding segment in formalin preserved specimens. The postero-lateral margin of this segment also is finely serrated and the specific name of the species has reference to this character. The urosome is 5-segmented (Fig. XIV. 4) but is very small compared to the size of the prosome. The pre-genital segment is rather small and bears the fifth pair of legs. In length it is only one-third of the genital segment, but it exceeds the latter in breadth. The genital segment is stumpy, much broader than long and without

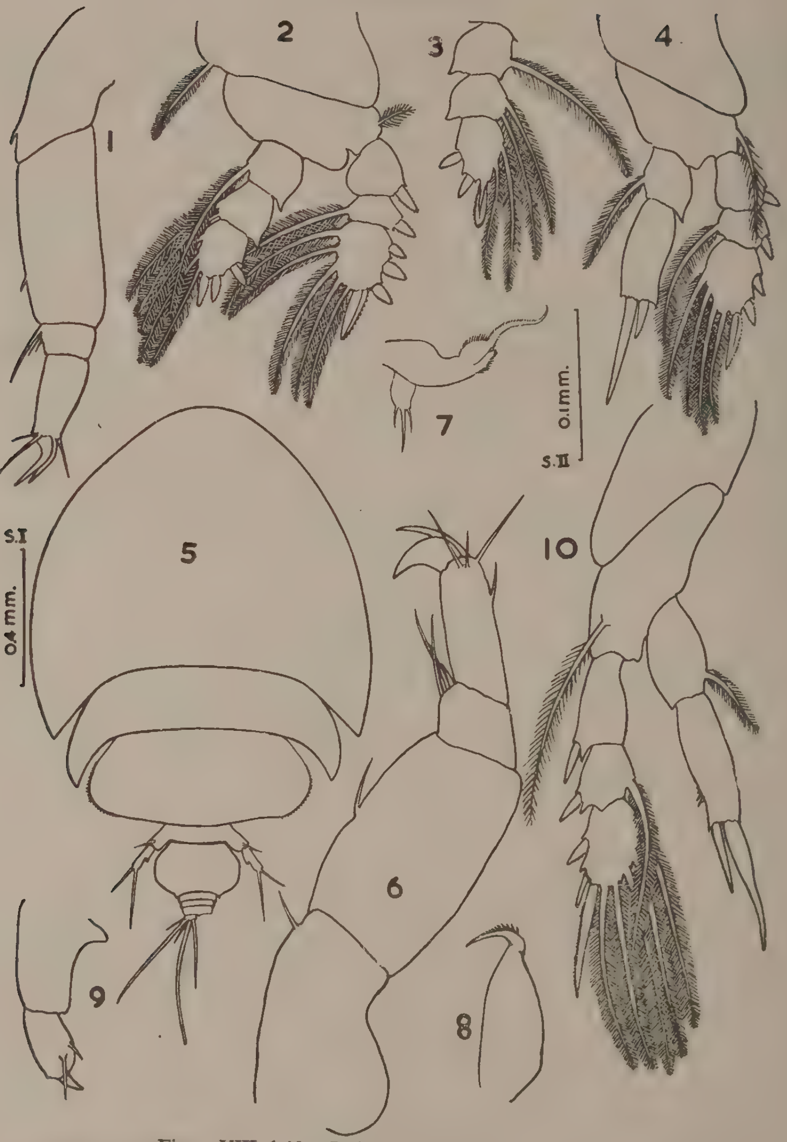

Figure XIII, 1-10. *Lichomolgus indicus* sp. nov.

1. Adult, female, antenna.
2. ,, ,, second swimming leg.
3. ,, ,, endopod of third swimming leg.
4. ,, ,, fourth swimming leg.

Lichomolgus serratipes sp. nov.

5. Adult, female, dorsal view.
6. ,, ,, antenna.
7. ,, ,, maxillule and mandible.
8. Adult, female, maxilla.
9. Adult, female, maxilliped.
10. ,, ,, fourth swimming leg.

(Diagrams 1 and 5 are drawn according to scale I and others according to scale II) any accessory spine or seta. The three abdominal segments are very inconspicuous and crowded together behind the genital segment. They are subequal in length but decrease gradually in breadth to the posterior side. The last segment bears the caudal rami which are distinctly wider than long. Each of the rami bears five setae, the second one from the inner side being the longest.

The antennule (Fig. XIV, 3) consists of eight segments which bear the following proportionate lengths :

1	2	3	4	5	6	7	8	
13.2	30.0	5.0	10.5	14.0	10.0	7.0	10.3	= 100

The first segment is rather short, bearing three stout setae. The second segment is very large, equivalent in length to that of all other segments combined. This segment bears a number of setae spread all along its length. Third segment is the shortest and characteristically wider in its anterior half. The fourth segment is longer than the third. Both these segments bear three setae each. The next four segments diminish both in length and width to the apex, quite a number of setae being borne on these segments. *Antenna* (Fig. XIII, 6) is very stoutly built and is equivalent in length to the antennnule in the natural position. They are held at right angles to the main axis of the body. Each antenna consists of four segments. First segment has a deep curve in its distal posterior margin and bears a solitary seta on the opposite margin. The second is the largest segment of the antenna and is barrel like, bearing one seta on its anterior margin at its mid-length. The third segment is the shortest of all and has three setae on its antero-lateral corner. The distal segment bears two claws and four setae ; three of the setae are apical and of unequal length, the fourth one is rather small and subapical on the posterior margin. *Mandible* (Fig. XIII, 7) consists of basal broader blade and a distal tapering lappet. The latter is lined on its both margins with fine spinules. The basal broader part carries a ridge with fine spinules on it on the postero-distal margin. The antero-distal margin bears a similar row of spinules. *Maxillule* (Fig. XIII, 7) is similar to that of the preceding species. *Maxilla* (Fig. XIII, 8) is rather simple. It is a rectangular appendage with an apical lash which, compared to that of the known species of the genus, is quite short ; the lash is provided with stiff hairs on one margin. *Maxilliped* (Fig. XIII, 9) is very small and consists of two segments. The first segment is larger than the second and has its proximal part expanded inwards. The second segment bears a small spine and two setae both of which are borne at some distance from the apex.

The four pairs of swimming legs (Fig. XIII, 10 & Fig. XIV, 1, 2 & 5) are borne by the four prosomal segments. The first three pairs are biramous, the ramus consisting of three segments. The last pair of legs are biramous, too, but the inner ramus consists only of two segments. The first pair of legs are slightly smaller than the following legs. The ornamentation of the swimming legs are as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	0	0	0	1	1	0	1	0	4	1	I	0	I	1	I	4	I	III
P_2	0	0	0	0	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	0	0	0	0	1	0	2	0	2	II	I	0	I	1	I	5	I	III
P_4	0	0	0	1	1	0			II			0	I	1	I	4	I	III

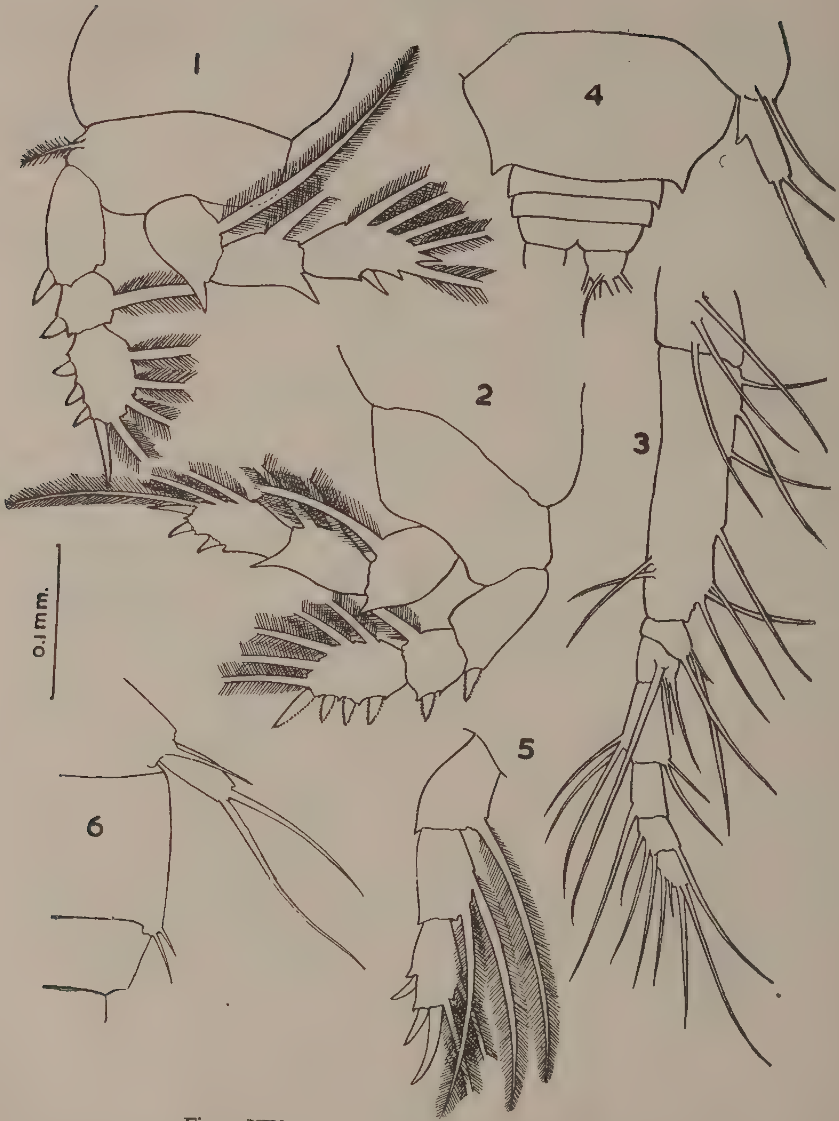

Figure XIV, 1-6. *Lichomolgus serratipes* sp. nov.

1. Adult, female, first swimming leg.
2. ,, ,, second swimming leg.
3. ,, ,, antennule.
4. Adult, female, fifth leg with parts of urosome.
5. ,, ,, endopod of third swimming leg.

Lichomolgus indicus sp. nov.

6. Adult, female, fifth leg with parts of urosome.

The fifth leg (Fig. XIV, 4) is 2-segmented, but the basal segment is completely confluent with the first urosomal segment. It bears a solitary seta on the distal outer angle. The distal segment is rather rectangular having two setae of unequal length on the terminal margin ; the inner margin of the distal segment is broken at about the midlength by an indentation which projects prominently towards the posterior side. The fifth legs, in their natural position, just reach the posterior margin of the genital segment. The female is 1.5 mm. long.

B. Male

See Addendum.

Lichomolgus brevifurcatus sp. nov.

Material examined : Two female and several male specimens of this species were obtained in the Gulf of Mannar from the starfish washings. The specimens were all in good condition and were pale yellow in colour. The holotype, the allotype and the paratypes are deposited in the Central Marine Fisheries Research Institute and have the registered numbers J. 662/13, J. 663/13 and J. 664/13 respectively.

A. Female

Description :

The Body : (Fig. XI, 11) is graceful, rather elongate, with the prosome and urosome merging into each other. The prosome is composed of only four segments, the cephalosome and the first metasomal segments having been fused completely to form a cephalothorax. The latter is the largest of the body segments and constitutes two-fifth of the whole body ; it is also quite wide, more than twice as wide as the last prosomal segment. A semi-spherical rostral prominence is present on the anterior margin. The posterior corners of this segment is smoothly curved. Of the remaining three segments the second is the longest and the third the shortest. These segments diminish in width gradually to the posterior side. All segments are provided with lateral expansions. The urosome consists of five segments, the fifth leg-bearing segment, the genital segment and three abdominal segments. The first two are of equal width while the last three decrease in breadth posteriorwards ; in length, however, the three abdominal segments show the reverse situation, namely, the last segment is the longest and the first the shortest. The genital segment is barrel-like and does not become narrowed in the posterior half. The caudal ramus is very short, distinctly wider than long. It is only half as long as the last abdominal segment. Each furca bears six setae, four of them much smaller than the other two.

The antennule (Fig. XI, 2) is 7-segmented, segments bearing the following proportionate lengths :—

1	2	3	4	5	6	7	
15.4	33.1	8.1	18.2	10.3	7.2	7.7	= 100

The second segment is the longest and is half as long as the length of all other segments combined ; the last segment is the shortest and bears a single aesthetask on its apex. All the segments are provided with a number of setae. The *antenna*

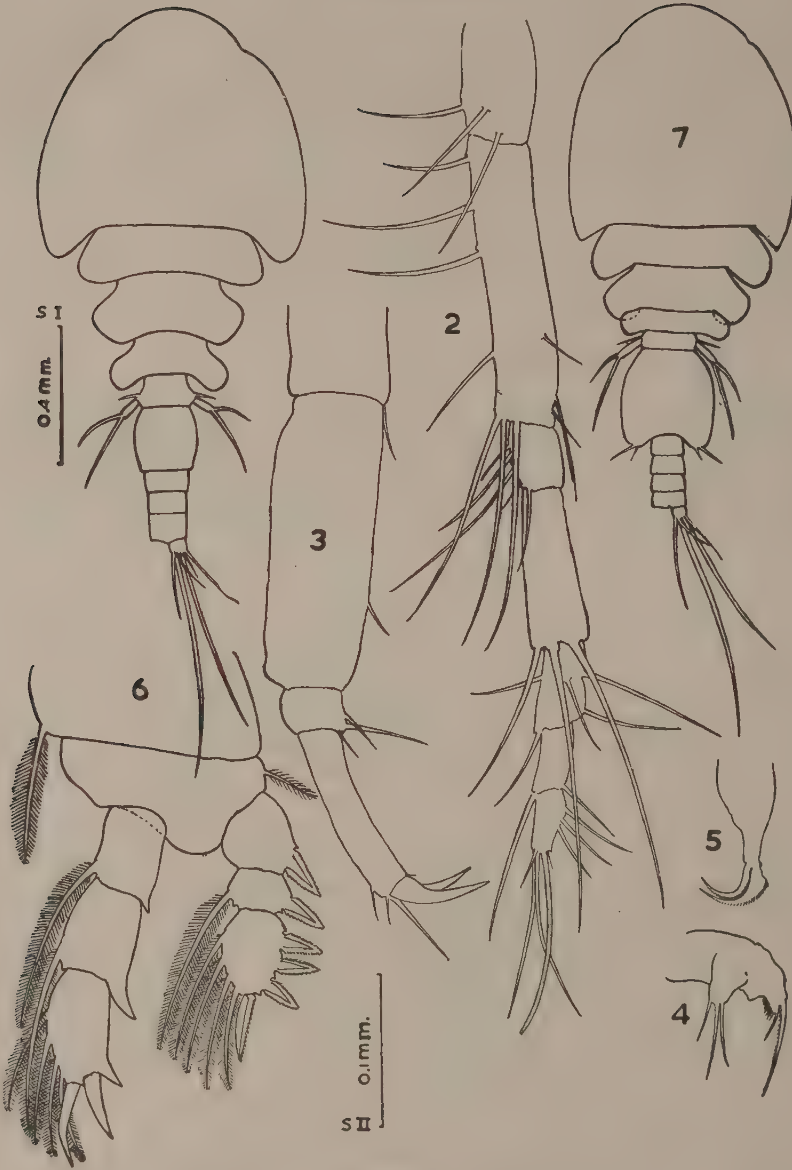

Figure XI, 1-7. *Lichomolgus brevifurcatus* sp. nov
1. Adult, female, dorsal view.
2. ,, ,, antennule.
3. ,, male, antenna.
4. ,, ,, mandible and maxillule.
5. ,, ,, maxilla.
6. ,, ,, first swimming leg.
7. ,, ,, dorsal view.
(Diagrams 1 and 7 drawn according to scale I and 2-6 to scale II)

(Fig. XI, 3) is stoutly built, only a little smaller than the antennule and 4-segmented. The first segment bears a solitary seta at its antero-distal corner. The second segment bears a seta on its anterior margin at about two-third the length. The third segment is provided with three setae of unequal length all on the distal anterior margin. There are two short spines and three setae on the last segment, besides a few hairs. Two of the setae are apical and one subapical. The *mandible* (Fig. XI, 4) is moderately developed with broader basal and narrower distal parts. The former carries a ridge at its distal outer margin and a number of large spinules on its distal inner margin. The apical lash is long and carries spines on the margins. The *maxillule* (Fig. XI, 4) is normal similar to those described for earlier species. The *maxilla* (Fig. XI, 5) with none of the spinules of the apical lash particularly strong ; the body proper narrower towards the distal part. *Maxilliped* is quite normal, short and stout, two-articulate, the last segment bearing a spine which is broad at the base.

There are four pairs of *swimming legs* (Fig. XI, 6 & Fig. XII, 1, 2 & 3) ; all are biramous ; the rami of the first three pairs of legs as well as the exopod of the fourth leg are 3-segmented, while the endopod of the fourth leg is only 2-segmented. The ornamentation of the swimming legs is as follows :—

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P$_1$	1	0	0	1	1	0	1	0	4	I	I	0	I	1	I	4	I	III
P$_2$	1	0	0	1	1	0	2	0	3	III	I	0	I	1	I	5	I	III
P$_3$	1	0	0	1	1	0	2	0	2	III	I	0	I	1	I	5	I	III
P$_4$	0	0	0	1	1	0			1	I		0	I	1	I	5	I	II

All the legs are more or less of equal length. In the first three pairs of legs the endopods are distinctly longer than the exopods while in the fourth leg the situation is reverse. The protopod in all cases is very much stumpy and large. *Fifth leg* consists of two segments. The basal segment, however, merges with the first urosomal segment, and bears a solitary seta at its outer upper angle. The distal segment is rather rectangular with the long axis more than twice as long as its short axis ; it bears two setae terminally and they are of unequal length. The length of the female is 1.6 mm.

B. MALE

The male (Fig. XI, 7) is much smaller than the female but is more robust in appearance. In the prosome the reduction in breadth from the first to the second segment is gradual while it is rather abrupt in the female. This is because of a proportionate increase in the width of second and third prosomal segments. The urosome is composed of six segments, the fifth leg-bearing segment, the genital segment and four abdominal segments. The first segment is the shortest ; in breadth it is only half as wide as the last prosomal segment. The genital segment is quite large and is equivalent in length to that of all other urosomal segments combined ; it is very much expanded laterally and bears two spines of unequal length on its postero-lateral corners. The abdominal segments are more or less of equal dimensions and form a column. The furcal rami are similar to those of the female. The male measures 1.5 mm.

All the appendages are identical with those of the female except the maxilliped which is well developed, subcheliform with a long curved hook ; it probably has a geniculate function. The second segment bears a seta on its inner margin at about its mid-length, and the third segment bears a single seta on its apical margin ; a number of stiff hairs, linearly arranged on its long axis, are present on the second segment.

Lichomolgus indicus sp. nov.

Material examined.—Four female and two male specimens were obtained along with the preceding species from the Gulf of Mannar in July 1960. A single female specimen was later obtained from the sponge washings of the same area. The type specimens, the holotype, allotype and paratypes are deposited in the Central Marine Fisheries Research Institute, Mandapam Camp and have the registered numbers J. 667/14, J 668/14 and J 669/14 respectively.

A. FEMALE

Description :

This (Fig. XII, 4) is much smaller species than the preceding one. In the prosome, the cephalosome is separate from the first metasomal segment but the line of demarcation is rather faint. The cephalosome bears a distinct rostral prominence. Both these segments are more or less of equal breadth. The following three prosomal segments diminish in width posteriorwards. In length they are subequal. The urosome consists only of four segments, the pregenital, the genital and two abdominal segments. The first segment is quite normal and bears the fifth pair of legs. The genital segment is partly divided at about its three-fourth length and the portion posterior to the line of division is narrower than that before it. Two spines of unequal length are present at the postero-lateral corners of the proximal division. Of the abdominal segments, the second is larger than the first, but they are both of equal width. Caudal ramus is very short, less than half the length of the last abdominal segment ; it is distinctly broader than long ; each ramus bears five setae, two of which are fairly long while other three are very small.

Antennule (Fig. XII, 5) is 7-segmented, the relative lengths of the different segments being as follows :

1	2	3	4	5	6	7	
14.2	32.5	6.1	15.0	13.4	9.4	9.4	100

While in the preceding species the terminal segment is the shortest antennular segment, in the present case it is third segment which is the shortest. The relative length of the second segment is similar in both cases. The setation of the different segments also bears certain kinship, especially in the presence of two very long setae on the distal margin of the fourth segment. However, no aesthetask is present on the terminal antennular segment. *Antenna* (Fig. XIII, 1) is quite normal, 4-segmented and having great resemblance to that of the preceding species. *Mandible* and *maxillule* (Fig. XIII, 6) are normally built and are as shown in the figure. *Maxilla* (Fig. XII, 7) is stouter than that of the earlier species, apical lash with spinules of uniform size ; the spine at the base strongly built. *Maxilliped* (Fig. XII, 8) is very small and 2-segmented ; the first segment bears a few spinules on its mid-inner margin ; the second segment bears a solitary seta at about its mid-length and a conical, broad-based spine at the apex.

The four pairs of *swimming legs* (Fig. XII, 9 and XIII, 2, 3 & 4) are borne by the last four prosomal segments respectively. Both rami are of about equal length in all legs except the fourth where the endopod is shorter because of its two segmented nature. The ornamentation of the swimming legs is as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	1	1	0	1	0	4	I	0	1	I	I	I	4	I	III
P_2	1	0	0	1	1	0	2	0	3	I	II	0	I	1	I	5	I	III
P_3	1	0	0	1	1	0	2	0	2	I	II	0	I	1	I	5	I	III
P_4	1	0	0	1	1	0			II			0	I	1	I	4	I	II

A number of differences can be noticed in the setal arrangement of the swimming legs of this species and this difference extends to the terminal endopod segments of all the four pairs of legs and in the terminal exopod segment of the fourth leg. In general the tendency in the present species is to a reduction in the number of spines. The fifth legs (Fig. XIV, 6) are 2-segmented, but, here again, the basal segment merges into the leg-bearing segment ; the terminal segment is a little more than twice as long as broad and bears two terminal setae, directed postero-laterally. The size of the female is 1.05 mm.

B. MALE

The male (Fig. XII, 10) exhibits the sexual dimorphism and is smaller than the female. The prosome is very similar in both cases. The urosome in male comprises five segments, the fifth leg-bearing segment, the genital and three abdominal segments. The first segment and the abdominal segments are very much identical with those of the female. The genital segment, however, is quite developed, has no trace of any sub-division and is more or less of uniform breadth throughout. Each postero-lateral corners of this segment bears a pair of spines. Caudal ramus is identical to that of the female. The male measures 1.00 mm.

Among the appendages only the maxilliped shows structural modifications from that of the female. While in the latter it is very dwarf and 2-segmented, here it is fairly large and with a long apical hook. The appendage bears great resemblance to that of the preceding species.

Remarks.—The genus *Lichomolgus* is an extremely vast group of animals, ' a lumber-room for those species that do not belong to any of the other genera ' of the

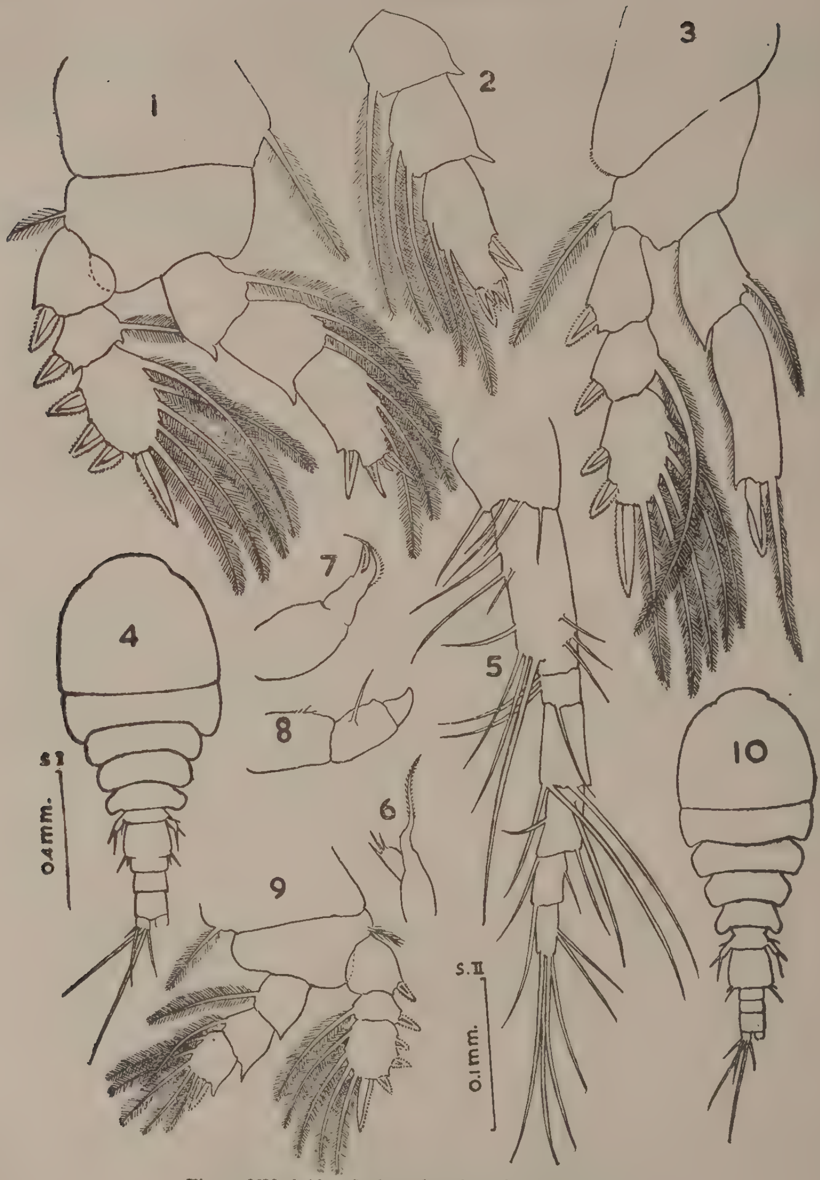

Figure XII, 1-10. *Lichomolgus brevifurcata* sp. nov.

1. Adult, male, second swimming leg.
2. ,, ,, endopod of third swimming leg.
3. ,, ,, fourth swimming leg.

Lichomolgus indicus sp. nov.

4. Adult, female, dorsal view.
5. ,, ,, antennule.
6. ,, ,, mandible and maxillule.
7. ,, ,, maxilla.
8. Adult, female, maxilliped.
9. ,, ,, first swimming leg.
10. ,, male, dorsal view.

(Diagrams 4 and 10 are drawn to scale I and others according scale II) subfamily Lichomolginae. The difficulty of obtaining large number of representatives, the meagreness of the descriptions of the several species and the innumerable number of species that have been assigned to this genus from various parts of the world at different times make a comparative study of the known species of this genus extremely delicate. To this must be added the fact that several species have been transferred and retransferred from genus to genus because of the disagreement that exists among the scientists as to the validity or otherwise of some of the genera of the subfamily Lichomolginae. No attempt is, therefore, made here, to determine the validity or synonymy of any of the species. The four species described in this paper do not correspond exactly to any of the known forms and, therefore, are treated as new.

Lichoomolgus serratipes is very near to *L. pteroidis* Della Valle but differs from it in several details :

L. pteroidis	*L. serratipes*
1. Size—not given. (ch. Stock, 1959)	Size 1.5 mm., female .76 mm. male.
2. The length-width ratio of the first prosomal segment is 40 : 60.	Length-width ratio of the first prosomal segment is 45 : 55.
3. The marginal serration of the second prosomal segment is visible from the dorsal side.	The marginal serration of the second prosomal segment not visible from the dorsal side.
4. Antennule 7-Segmented.	Antennule 8-segmented.
5. The terminal segment of the first endopod of male carries a large spinular growth which is half the length of the segment itself.	The spinular growth on the terminal segment of the first endopod is hardly one-fourth of the segment.
6. The post-genital segments of urosome are clearly visible from the dorsal side. The middle region of the lateral margins of the male genital segment is smooth.	The post-genital segments of the urosome in male are completely covered by the large posterior flap of the genital segment. The middle region of the lateral margins of the genital segment of the male is toothed.
7. In the female the spiniform projection and the lateral expansion of the fifth leg well beyond the $\frac{3}{4}$ length.	The spiniform projection and the lateral expansion of the fifth leg in front of half the length.

Recently, Stock has described another species, *P. pterophilus* from the Indonesian waters. Unfortunately I have not seen the description of the species.

Both *L. pteroidis* and *L. serratipes* (and probably *L. pterophilus*) are closely allied to the four species of lichomolgids, *L. venustus*, *L. patulus*, *L. audens* and *L. asaphidis*. Humes that have recently been added from Madagascar (Humes, 1958). In all these forms the antennule is 8-segmented, the body, particularly the first prosomal segment, is very much broadened (except in *asaphidis*), the genital segment in both sexes is very large and there is complete fusion between the cephalosome and the first pedigerous segment. There is great similarity also in the oral appendages and the swimming legs.

L. holothuriae appears to be a true representative of the subgenus *Stellicola*. This species, together with *L. curticaudata* (Thompson & Scott) *L. asterinae* Bocquet, *L. frequences*, *L. astropectinis*, *L. luidiae* and *L. lautus* Humes & Cressey constitute a closely related group of species. All are characterised by (a) an 8-segmented antennule ; (b) a 3-segmented antenna and (c) the setal formula for the fourth endopod of 0I, II 1.

L. holothuriae is quite close to *L. curticaudatus* and may even be conspecific with it. However, it is treated as a separate species because of the following reasons : (1) There is complete fusion of the cephalosomal segment and the first pedigerous segment in *L. holothuriae* while they are distinctly separate in *L. curticaudatus.* (2) The urosome is less than one-third the length of the prosome in *L. curticaudatus* ; in the present species it is clearly more than one-third the length of the prosome. (3) In *holothuriae* the genital segment is longer than the next three segments joined together ; in *curticaudatus* it is distinctly shorter. (4) The maxilla is different in the two species.

The nearest relative of *L. brevifurcatus* is perhaps *L. robustus* Thomp. & Scott, but the differences between the two forms are many and are noted below : (1) in *L. robustus* the cephalosome and the first metasomal segment are separate while in *L. brevifurcatus* they are completely fused. (2) In *L. robustus* the genital segment is 1½ times wider than long ; in *L. brevifurcatus* the breadth and length of the genital segment are the same. (3) A distinct rostral prominence is visible from the dorsal side in the present species, whereas it is not visible in *L. robustus.* (4) Caudal ramus in *L. robustus* is only a little shorter than the last abdominal segment ; it is only less than half the length of the last abdominal segment in *L. brevifurcatus.* (5) The longest furcal seta in the present form is longer than the urosome while it is less than half the length of the urosome in *L. robustus.* (6) The last exopod segment of the fourth leg in *L. robustus* bears three spines on the outer margin and one spine terminally while in the present case there are only two spines on the outer margin besides the apical spine.

L. indicus is quite distinct enough from all other species in the very general appearance and comparatively smaller size. The two-segmented nature of the abdomen brings down its immediate probable relatives to quite a few. The species is easily identified by the combination of the following characters. (1) Cephalosome and the first metasomal segment separate. (2) The fifth leg-bearing segment is very short, being the shortest of the urosomal segment. (3) The genital segment exhibits a partial division at about three-fourth the length in its distal part ; the posterior division is narrower; at the postero-lateral corner of the latter there is a pair of spines. (4) The genital segment is equivalent in length to that of the two abdominal segments joined together. (6) In the antennule the second segment is the longest and the third the shortest. (7) The setal formula of the swimming legs is peculiar and is given above in the text.

SUMMARY

Eleven new species of cyclopoid copepods, four belonging to the section Siphonostoma and the rest to the section Poecilostoma are described in detail. Six of the species are represented by both the female and the male sexes while others are known only from the females. The material of the present investigations was collected both from the Gulf of Mannar and the Palk Bay off Mandapam on the south-east coast of India during the months of May, June, July and August, 1960. The collections were made in the inshore waters and the methods of collection are discussed.

The composition of the cephalosomal appendages of the siphonostomatous cyclopoids is briefly considered. The present study shows that there are four pairs of oral appendages, the mandible, the maxillule, the maxilla and the maxilliped besides the preoral antennule and antenna on the cephalosome.

The following genera are represented in the present collection :

1. *Asteropontius* Thompson & Scott.
2. *Cryptopontius* Giesbrecht.
3. *Hemicyclops* Boeck.
4. *Pseudoanthessius* Canu.
5. *Macrochiron* (*Macrochiron*) Brady, Sewell.
6. *Lichomolgus* Thorell.

A key to the identification of the various known species is provided for the genus, *Asteropontius*. In other cases the species described in this paper are diagnosed and a comparison between the forms treated here and the previously known forms is rendered.

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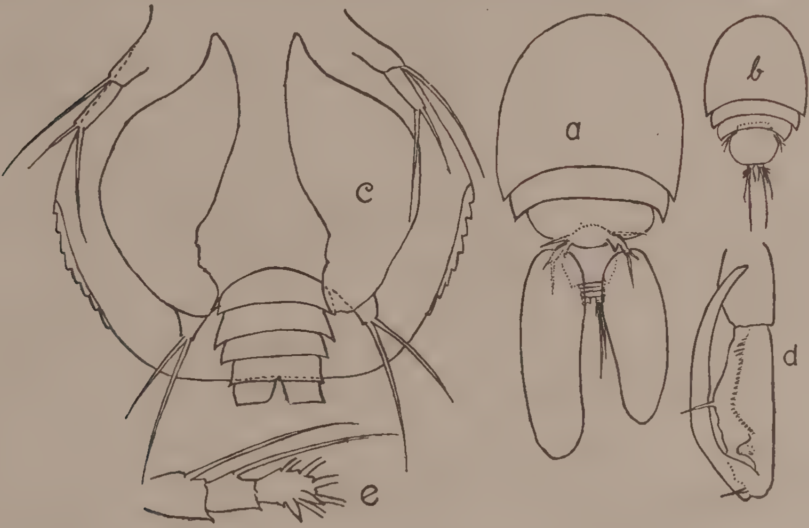
ADDENDUM

Lichomolgus serratipes sp. nov.

MALE

Size—0.76 mm. The male (Fig. 1, b) is only a little more than half the length of the female. The general body shape corresponds to that of the female. The sexual dimorphism is expressed in the structure of the maxilliped and the urosome.

The maxilliped (Fig. 1, d) is very large, the terminal segment carrying an incurved claw which is equivalent to the two segments combined. The second segment carries also two setae, one at about the mid-length and the other near the base of the claw. There is a row of spinules along two-third the length of this segment. An elevated ridge is present on the distal area, in continuation with this row of spinules.



Lichomolgus serratipes, sp. nov.

Fig. 1, a— Adult female, dorsal view.
,, b— ,, male, dorsal view.
,, c— ,, female, urosome, ventral view.
,, d— ,, ,, maxilliped.
,, e— ,, ,, first endopod.

The urosome is 6-segmented, consisting of the fifth-leg bearing segment, the genital segment and four abdominal segments. All segments are very short and crowded together except the genital segment which is exceedingly large and grows both posteriorwards and sidewards, covering most of the abdominal segments. The caudal rami are, however, visible from the dorsal side.

The fifth leg is rectangular, without any lateral expansion or spinular growth. The basal segment, as in the female, is confluent with the first urosomal segment and carries one seta. The distal segment carries two apical setae. All other structures, including the terminal segment of the first endopod (Fig. 1, e) are similar to those of the female.

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PERODERMA CYLINDRICUM HELLER, A COPEPOD PARASITE OF *SARDINELLA ALBELLA*[*]

By P. SAM BENNET[†]

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THE genus *Peroderma* Heller (1868) includes four species, *P. cylindricum* Heller, *P. branchiata* Basset-Smith, *P. petersi* Richiardi and *P. bellottii* Richiardi. According to Wilson (1917) the last two species are poorly described and certainly do not belong to *Peroderma*. As Basset-Smith (1898) had only a single specimen he did not make any attempt to study the appendages. This precludes a detailed comparison of his species with the genotype. Brian (1906) and Wilson (1917) have considered *P. cylindricum* and *P. branchiata* as synonymous. The object of the present paper is not to discuss the synonymy but to give a detailed description of *P. cylindricum*.

The original description of the species was supplemented by Monterosso (1922, '26 and '30) who gave a description of the structure and histology of the mature adult and the juvenile. A perusal of the available literature on the genus shows that information of the appendages is still incomplete. I was fortunate to get a rich collection of specimens which facilitated a detailed study.

Peroderma cylindricum Heller

Peroderma cylindrica Heller, 1868, P. 250, Pl. XXV, fig. 6.

Peroderma branchiata Basset Smith, 1898, P. 13, Pl. VII, fig. 2.

Peroderma, cylindricum Brian, 1906, P. 93.

Material: Twenty two adult females, twelve with egg strings, were collected from *Sardinella albella* (Val.) caught at Mandapam, South India, during 1958-59.
Adult female (Fig. 1)

The general shape of the body is as described by Heller and Basset Smith. Body is clearly demarcated into a swollen head, a narrow cylindrical neck and a stout cylindrical trunk with a slight dorsoventral flattening. The head and neck remain at right angles to the long axis of the trunk and the latter is produced slightly beyond the point of insertion of the neck. The trunk is enveloped in a loose chitinous jacket very much detached from the body flesh more or less as in some Lernaeopodidae. The head is somewhat globular, irregularly lobed and carries a bunch of long rhizoid like outgrowths originating from a common base or peduncle emerging from the middle of the ventral surface of the head. The dorsal side of the head shows a dark spot, the rudimentary eye.

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First antennae are somewhat club-shaped, three jointed structures carrying several stiff setae ; the third joint is comparatively very long and carries a long seta. Second antennae are three jointed, subchelate prehensile organs. The first joint is short, second stout with its inner distal part produced into a triangular process against which the long falcate third joint closes. The oral appendages are sunk into a deep cleft just anterior to the origin of the head processes. The mouth tube is bulbous and slightly protruding, its free border with a fringe of fine hairs. The mandibles are simple pointed stylets enclosed within the mouth tube. Maxillae are close to the mouth tube, each is two jointed, the distal joint bearing two long spine setae. Maxillipede are three jointed, the third joint is slightly curved and the second joint bears a small blunt accessory claw. There are three pairs of legs, the first two are placed fairly close together while the third is separated from the second by a longer interval. The first two pairs of legs are typically biramous, the rami two jointed and carrying fairly long setae. The third leg is uniramous, indistinctly two jointed and carries a few short spines and a long terminal seta. A pair of incipient caudal processes, the anal laminae, are also present.

Newly hatched larva (Fig. 2)

The newly hatched larva is an advanced metanauplius or a copepodid. It is 0.75 mm. long and has an elongate ovate body. The carapace is ovate, slightly more than half the total length of the body. The large eye is situated anteromedially. Behind the carapace there are four distinct somites. The first free somite carries the second pair of legs. The segment carrying the first legs is fused with the carapace. The second free segment carries the third pair of legs, a pair of small tubercles surmounted by a spine. The fourth free somite carries a pair of broad and flattened anal laminae, each carrying two pairs of plumose setae, the inner pair is considerably longer than the outer.

The cephalic appendages are very much like those of the adult. The first two pairs of legs are biramose but the rami are one jointed.

Remarks

As far as I am aware the appendages of *Peroderma* have not been adequately described and none of the previous authors seem to have observed the anal laminae. It may be observed that in the structure of the appendages *Peroderma* falls in line with that of the other members of the family particularly *Lernaenicus* and *Phrixocephalus*, two other genera having the same mode of life.

In the case of all the other genera so far studied the genital segment is partially or completely free, projecting through the skin of the host. In *P. cylindricum* the entire trunk is enclosed within the body of the host and the egg-tubes alone project. When the egg-tubes are missing a small hole, extremely difficult to locate, alone reveals the presence of the parasite. It seems to show a decided preference for *S. albella*. As a rule each host is infested with a single parasite. The parasite penetrates the lateral muscles and reaches the posterior aorta near the kidneys where it is assured of a plentyful supply of blood to feed on. The presence of an oral tube with stylet like mandibles shows that the entire nourishment is absorbed through the mouth and that the cephalic processes serve only to anchor the parasite firmly.

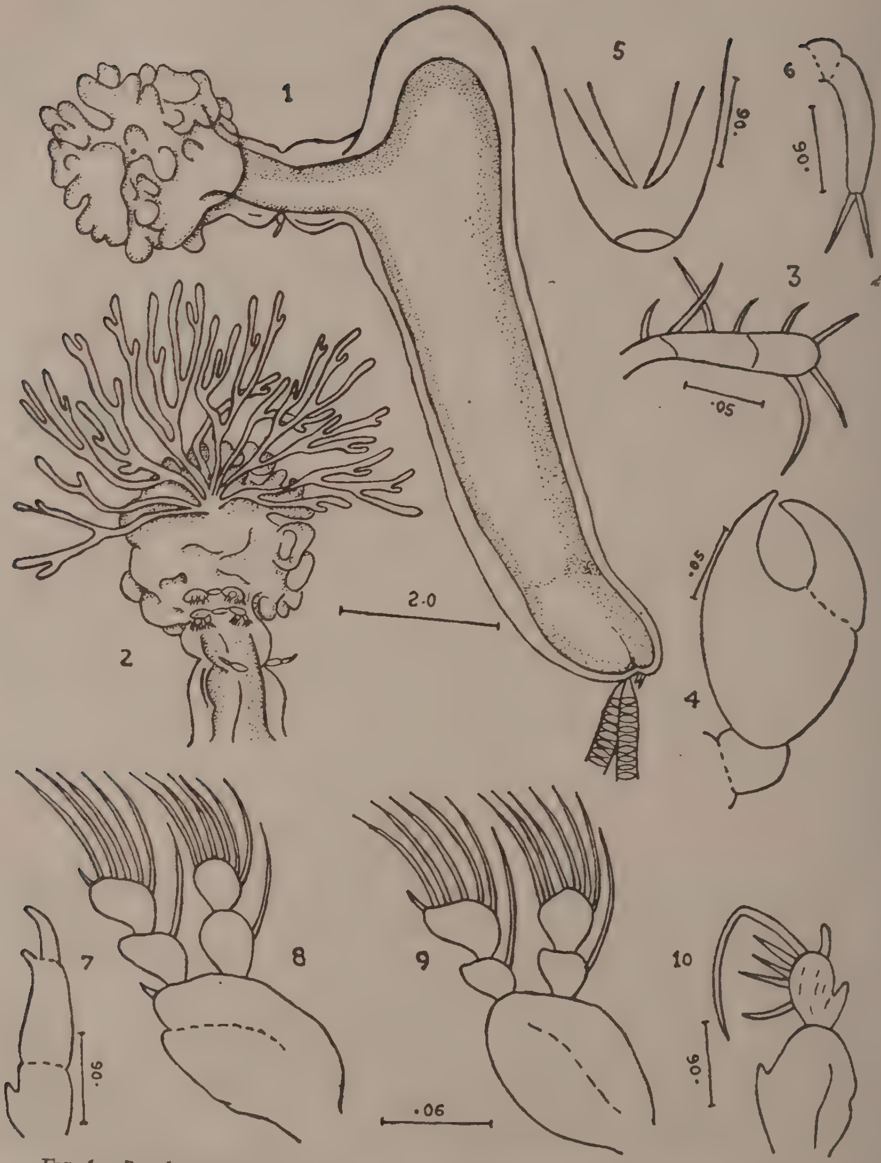

FIG. 1. *Peroderma cylindricum* 1, female, rhizoidal outgrowths removed. 2, head and neck ventral view. 3, first antenna. 4, second antenna. 5, mouth tube with mandibles. 6, maxilla. 7, maxillipede. 8, first leg. 9, second leg. 10, third leg. Magnifications in millimeters.

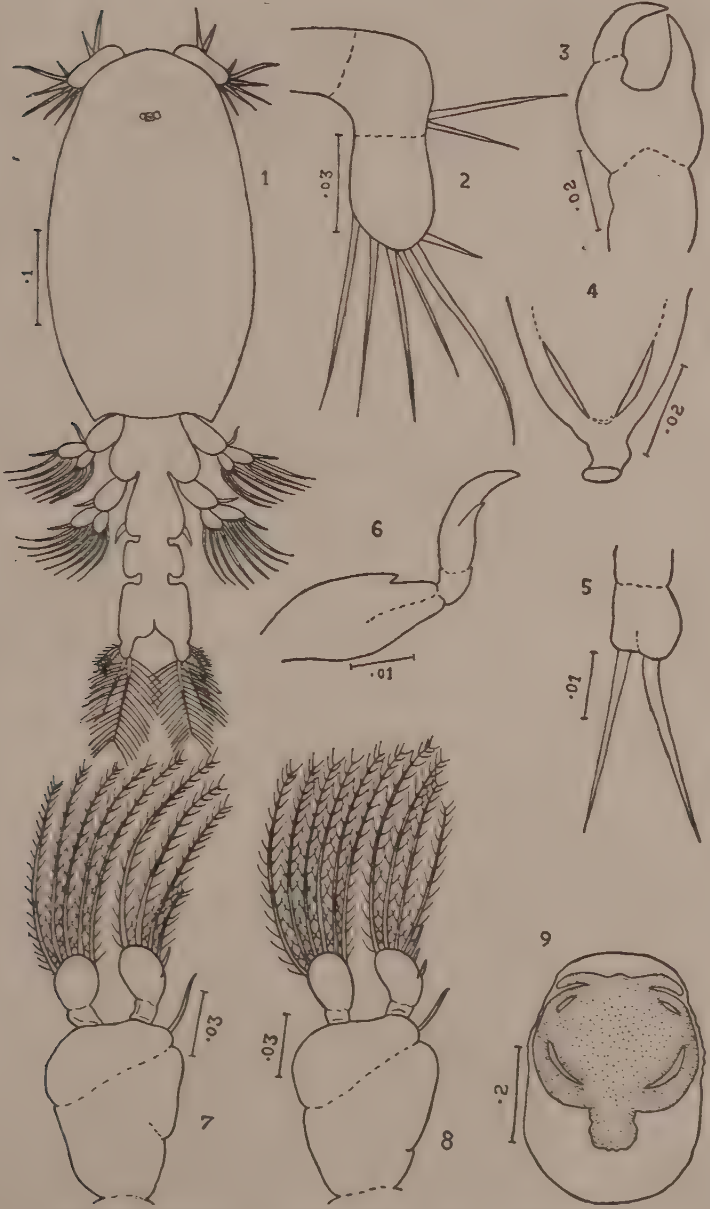

FIG. 2. *Peroderma cylindricum*. 1, newly hatched larva. 2, first antenna. 3, second antenna. 4, mouth tube with mandibles. 5, maxilla. 6, maxillipede. 7, first leg. 8, second leg. 9, egg with embryo. Magnifications in millimeters.

According to Wilson the larva of *Peroderma* is unknown. According to him the egg of lernaeids hatch out in the third metanauplius stage and that of lernaeopodids in the first copepodid stage. This observation is correct with regard to *Peroderma* as is evident from the structure of the larva described above. Though every effort was made to keep the larvae alive all of them died without moulting on the fourth day. The fact that they continued to live without further metamorphosis for four days perhaps shows that the larvae must at this stage contact a host for further development.

The adult is an extremely degenerate parasite but surprisingly its appendages show an exact resemblance to those of the larva. The only difference that could be seen is in the legs ; those of the adult have two jointed rami while those of the larvae are one jointed. Thus with regard to the appendages *Peroderma* exhibits progressive metamorphosis.

ACKNOWLEDGMENTS

I wish to express my thanks to Dr. S. Jones for his keen interest and encouragement in this study and to Dr. N. Krishna Pillai for critically going through the text.

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J. Mar. biol. Ass. India, 1961, 3 (1 & 2) 75-86

OBSERVATIONS ON THE HABITS AND POST-EMBRYONIC DEVELOPMENT OF A PARASITIC BRANCHIURAN *ARGULUS PUTHENVELIENSIS* RAMAKRISHNA

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INTRODUCTION

A FEW specimens of the cyprinid fishes *Esomus danrica* (Ham.) and *Puntius vittatus* Day collected from a freshwater pond at Udayamperoor, twelve miles south-east of Ernakulam, Kerala State, were found infested with an ectoparasite which was identified as an argulid. Later on, *Macropodus cupanus* Cuvier, an anabantid fish and *Panchax panchax blochii* (Arnold) a cyprinodontid were also found to carry the same parasite. On the advice of Dr. S. Jones, Director, Central Marine Fisheries Research Institute, two specimens were sent to the Zoological Survey of India and were identified as new by Shri G. Ramakrishna. He (1959) named the new species *Argulus puthenveliensis* as was suggested by the writer and described it. During the subsequent collections many mature specimens were obtained which facilitated the study of the habits and post-embryonic development of the parasite.

OBSERVATIONS

Esomus danrica carrying *A. puthenveliensis* was kept in a glass jar for observation. Two of these parasites were first detached from the host and kept in a specimen tube. On introducing a fish into this container, the parasites were quick in attaching itself to any part of the host's body, though at times they failed. After getting a hold on the host initially at such points as the caudal peduncle, the fins or the sides of the trunk, they tried to move to other regions of the body. For example, it was observed that they moved slowly from the place of initial attachment to other places such as the dorsal surface of the body posterior to the dorsal fin, the base of the pectoral fin, especially the posterior side and the dorsal surface of the head of the fish, thus showing certain preferences for the site of eventual attachment. The parasite clung to the host's body with its posterior end turned towards the rear end of the fish. Occasionally it pushed its anterior end between the scales, probably for a better and easier penetration by the sting.

It was interesting to note that the hosts always struggled to escape from the parasite *Puntius* and they even devoured the fully mature parasites. This peculiar behaviour was noticed twice during my observations. In both the cases the parasites were mature females measuring about 4.5 mm. and the hosts were *Macropodus cupanus* Cuvier of 37 mm. in length and *Puntius vittatus* Day 30 mm. long. On dissecting the fishes the parasites were recovered from their stomachs. It is probable that these fishes caught them by the head as only the heads were injured.

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Copulation : Two fully mature specimens of *A. puthenveliensis* (one male and one female) were transferred into a small petri dish containing a little water and observed under the binocular microscope. The male *A. puthenveliensis* clasped the female, on the dorsal side by the posterior thoracic legs. The abdomen of the male was twisted under that of the female, on either side, so that the male genital opening was brought in direct contact with the spermathecal openings of the female. This method of copulation of *A. puthenveliensis* agrees with that of *A. viridis* described by (Martin, 1932). The copulation was continued for 32 minutes after which the pair separated. From the study of subsequent copulations it was found that the duration of copulation varied from 32 to 37 minutes and was irrespective of the number of eggs subsequently laid by the female. In two out of five subsequent copulations observed, the pair did not separate, but the male continued to be on the female's back even while it was laying the eggs.

Egg laying : Five minutes after the completion of copulation, the egg laying was started which continued for 10-11 minutes. The eggs were laid on the side of the glass jar. But later, they were made to lay the eggs on a ring of transparent plastic sheet for easy examination.

The eggs were oval in shape and white in colour as noted in the case of *A. viridis* Martin (1932). The number of eggs varied from 140-204 in fully mature ones. But the young ones, soon after attaining maturity laid fewer eggs, about 20 to 25 eggs at a time. Later, the number of eggs increased. The eggs were found to be laid in definite rows. The number of rows varied from one to as many as five or six. In each row they were placed end to end. Each egg was enveloped in a gelatinous substance which hardened on coming into contact with water as was noticed by Wilson (1904) in *A. americanus*. Unlike *A. catastomi*, *A. americanus* and *A. maculosus* Wilson (1907) the envelope of the egg was uniform in *A. puthenveliensis*.

Development : The fertilized eggs were kept at 30°C and periodically observed until all were hatched out. These eggs did not fail to develop even when they were scraped off from the sides of the container for close examination. The eyes were developed after the 6th day and the eggs started hatching after 13 days and 21 hours. The duration of hatching was found to vary in the different sets from 30 to 48 hours irrespective of the number of eggs, the temperature being kept constant. The proportion between the total number of eggs and the number of unhatched eggs varied from 102 : 1 to 154 : 15 while in some sets all the eggs hatched out. The rate of hatching was found to be varying from 2.6 to 4.2 eggs per hour (Table I).

Post-embryonic development : The post-embryonic development of *A. puthenveliensis* was studied in detail.

The newly hatched larva was very active and swam about freely. When a young fish was introduced the larva promptly got attached to it. The length of the newly hatched larva varied from 0.525 to 0.56 mm. The carapace was oval. The posterior lobes of the carapace covered the first two pairs of thoracic legs. The carapace was fringed with chitinous ciliary processes and spinules, extending upto the level of the compound eyes. The first antenna was like that of the adult in general appearance. The proximal segment was present unlike *A. japonicus* Tokioka (1936) ; but it did not bear the posterior spines. The second segment had a long and pointed lateral hook and an anteriorly directed blunt spine which had not developed a hook. The third and fourth segments were distinct and bore three prominent setae at the distal end. The second antenna had only three well defined segments, the basal one being the largest and bore a posterior spine. The distal segment had a strong curved claw. The proboscis had essentially the same structure as in the adult. The preoral sting was small. The first maxilla situated on the sides of the proboscis was three segmented. The proximal segment was bulky and the distal one had two curved claws. The ventral of these two claws had four forwardly directed curved spines which decreased in size from the base of the claw to its tip. The dorsal claw had a single posteriorly directed curved spine. The basal segment of the first maxilla was provided with a pair of inwardly directed spines, one anterior and inner and the other posterior and outer in position. The second segment had a similar spine on its posterior inner margin. The five segmented second maxilla had developed a pair of spines at the posterior end of the basal segment, one outer and the other inner. These spines represented the inner and middle spines of the adult. The two pairs of post-maxillary spines were developed, the anterior pair being just posterior to the proboscis, on either side and the posterior pair in a level with the first thoracic legs. The thoracic appendage, were all well developed unlike *A. japonicus* Tokioka (1936). They had coxae and bases bearing segmented endopods, (except in the second pair) and unsegmented exopods. The first thoracic leg had an endopod of three segments with three small plumose setae at its tip. The third and fourth legs had endopods of two segments each ; but the second leg had one segment only. These thoracic legs had not developed distinct precoxae.

TABLE I

Details of observations on *A. puthenveliensis*

Number of the batches of eggs	I	II	III
Duration of copulation (in minutes)	37	33	35
Duration of egg laying (in minutes)	10	11	11
Number of eggs	204	154	140
Duration of embryonic stage	13 days and 21 hours.	13 days and 21 hours.	13 days and 21 hours.
Time taken for complete hatching of the egg mass (in hours)	48	54	49
Number of unhatched eggs	2	15	nil
Average rate of hatching (per hour)	4.2	2.6	2.9
Sex ratio of young ones	11 : 6	11 : 7	11 : 6

The abdomen was broader than long and the length was less than 1/9 of the total length of the body. The caudal rami were prominent and bore stiff and short setae. The sexes could be distinguished in this stage. The two pairs of respiratory areas were clearly visible. The anterior one which was club-shaped extended laterally around the posterior one.

No change in structure was noticed until the second day after hatching when the larva increased in size and further approached the adult shape. The ciliary processes were altogether absent unlike *A. japonicus* ; but the spinules were still present. The alae of the carapace did not reach the posterior end of the second leg. The basal segment of the first antenna had developed two posterior spines, one outer and the other inner. The second antenna in this stage was four segmented as a result of the division of the basal segment of the earlier stage. The paired post-antennal spines also appeared. The first maxilla became four segmented due to the division of the basal segment. The second segment was large and bore two posterior spines. The second maxilla remained unchanged. There was no modification in the swimming legs except for the increase in size.

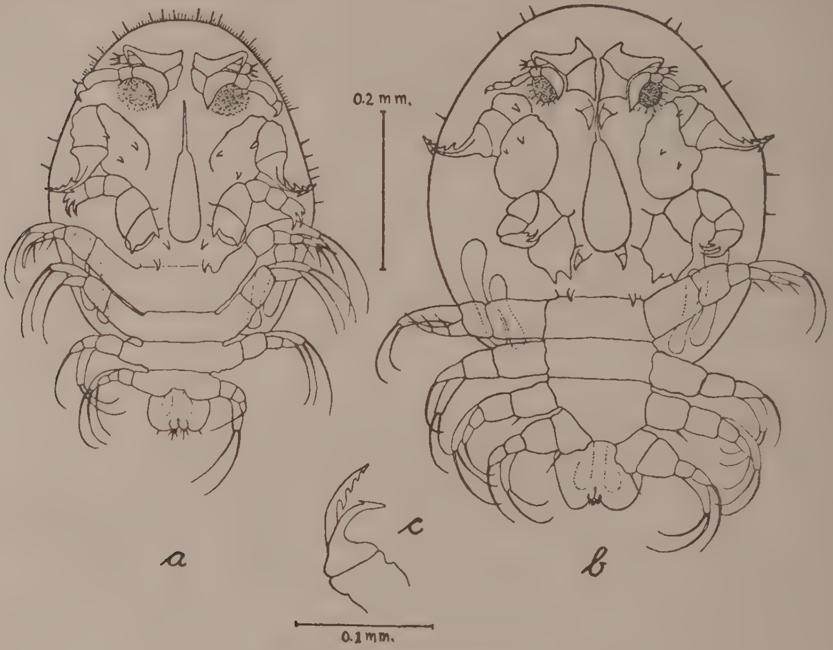

FIG. 1. *Argulus puthenveliensis.*

(a) Newly hatched larva, ventral view ; (b) 2 days old larva, ventral view ; (c) Dorsal view of the tip of the first maxilla of 2 days and 12 hours old larva showing the claws.

When the larva was 4 days old the carapace had scattered spinules on the outer margin. The carapace was nearly as broad as it was long and the alae just reached the second pair of legs. The anterior spine of the second segment of the antenna developed a hook. The second antenna remained four segmented ; but the claw at its tip was reduced in size. The second segment of the first maxilla enlarged and the first maxilla attained maximum development as clasping organs. The suction cup could be seen formed inside the second segment of the first maxilla. The second maxilla developed an outer spine at its base—the outer one of the adult.

The legs developed distinct precoxae and in the female the coxae of the last pair of legs began to enlarge posteriorly to form the natatory lobe of the adult. A number of spines appeared on the ventral surface in front of the anterior marginal groove and along the margin of the carapace especially adjacent to the respiratory areas. The abdomen was a little more than 1/7 of the total length. The caudal rami remained the same.

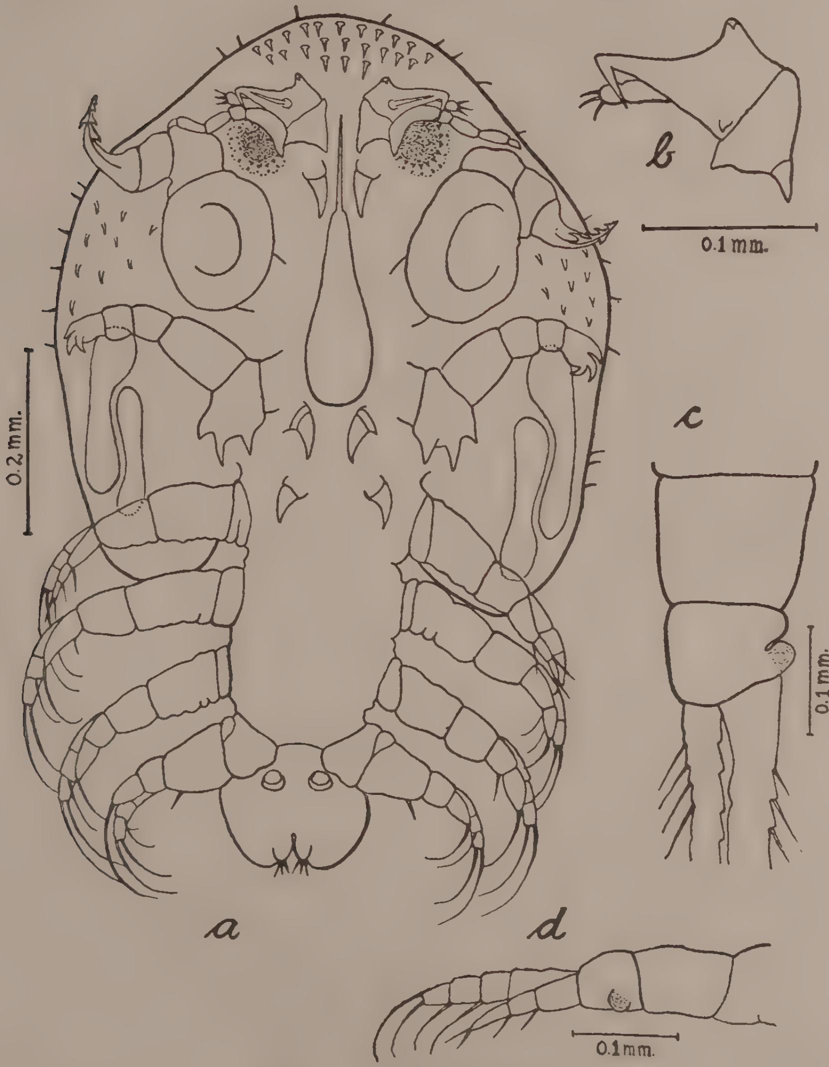

FIG. 2. *Argulus puthenveliensis.*

(a) 4 days old larva, ventral view; (b) First antenna of 4 days and 12 hours old larva; (c) Second leg of 5 days old larva showing the rudiment of flagellar process (lateral view); (d) First leg of 5 days and 12 hours old larva showing rudiment of flagellar process.

On the 5th day the suction cup was better developed. In this stage the rudiment of the flagellar process of the adult appeared in the form of small processes at the distal end of the base of the first and second pair of legs. When the larva was 5 days and 12 hours old the triangular processes at the margin of the ribs of the suction cup and its musculature could be clearly seen within.

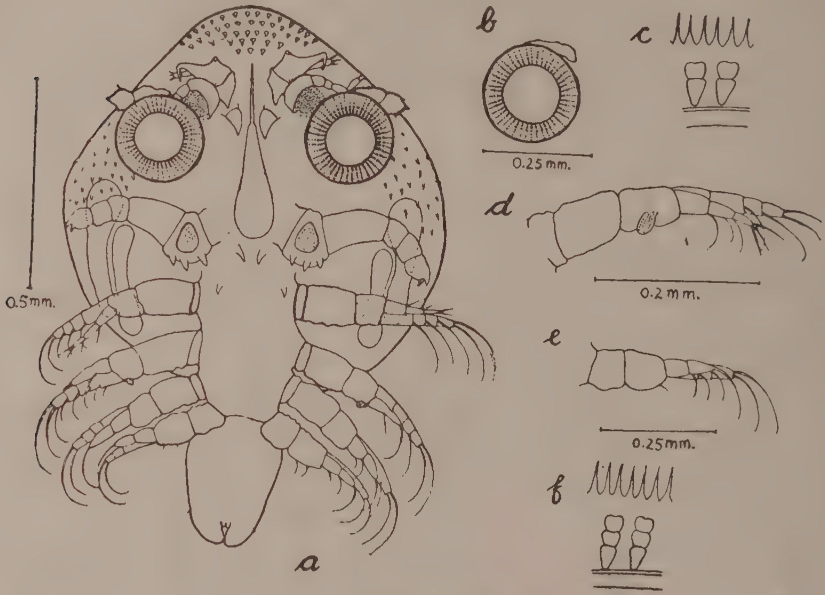

FIG. 3. *Argulus puthenveliensis.*

(a) 6 days old larva, ventral view ; (b) Suction cup with residuum of the first maxilla of 6 days and 12 hours old larva ; (c) Rib of suction cup of 6 days and 12 hours old larva ; (d) First leg of 6 days and 12 hours old larva showing the club-shaped rudiment of the flagellar process ; (e) Fourth leg of the same larva ; (f) Rib of suction cup of 7 days and 12 hours old larva.

On the 6th day the suction cup was exposed by the rupture of the second segment of the first maxilla. The distal segments of the first maxilla got reduced considerably. The rudiment of the flagellar process increased in size and became club-shaped. The exopods became segmented and had developed long plumose setae along their posterior surface. The endopods of the second pair of legs remained unsegmented. The lobes of the carapace reached the third pair of legs. In the male the abdomen elongated. The anal sinus became deeper and was more than 1/5 the length of the abdomen. At the age of 6 days and 12 hours the larva had a small residual portion of the distal segments of the first maxilla without any trace of segmentation. The first antenna developed a posterior spine on the inner side of the second segment. The second antenna had a highly reduced claw at its tip. The female had better developed natatory lobes. The rudiments of the flagella increased in size ; but did not develop any setae. The rib of suction cup had one big piece and a small one.

The larva after 7 days and 12 hours developed more spines on the carapace. The second antenna bore setae on the second and third segments. The fourth one had three stiff setae instead of the claw of the earlier stages. The residuum of the first maxilla got further reduced. The rib of the suction cup had one more smaller piece. The flagellum in this stage was well developed and bore two short plumose setae.

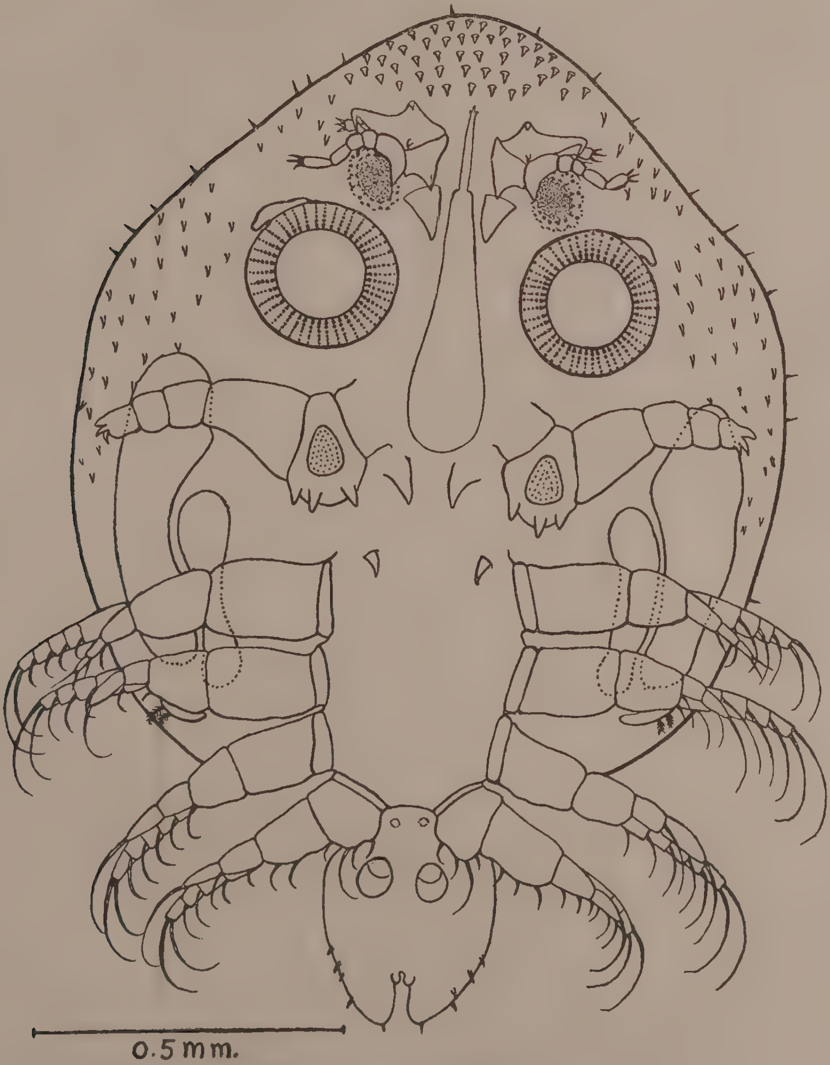

FIG. 4. *Argulus puthenveliensis.*

7 days and 12 hours old female larva, ventral view.

TABLE II

Measurements (in mm.) of the Larval Stages and Adults of Argulus puthenveliensis *Ramakrishna*

	Larval Stages													Adults	
Age in days	0	1	2	3	4	5	6	7	8	9	10	11	12	13♀	13♂
Total Length	0.525	0.525	0.593	0.703	0.725	0.841	1.291	1.363	1.363	1.457	1.740	2.088	2.204	3.143	2.928
Length of Carapace	0.319	0.319	0.377	0.522	0.522	0.667	0.667	0.986	0.986	0.995	1.305	1.218	1.305	2.286	1.857
Breadth of Carapace	0.268	0.283	0.326	0.464	0.493	0.587	0.725	0.841	0.899	0.841	1.189	1.16	1.131	2.114	1.571
Length of Abdomen	0.065	0.065	0.065	0.087	0.131	0.116	0.319	0.348	0.293	0.319	0.435	0.754	0.812	0.571	1.714
Breadth of Abdomen	0.068	0.073	0.087	0.116	0.102	0.152	0.232	0.276	0.232	0.261	0.293	0.334	0.348	0.914	0.429
Sucker Diameters	..	..	..	..	..	..	0.179	0.203	0.203	0.218	0.261	0.261	0.261	0.400	0.400
	..	..	..	..	..	..	0.189	0.203	0.189	0.218	0.261	0.232	0.261	0.400	0.400

In the female the natatory lobes were fully developed and had seven plumose setae. The abdomen had spinules on its outer margin. The anal sinus was deep and the anal papillae were small and situated at the anterior end of the sinus. In the male the abdomen was longer. Its length was a little less than 1/3 the total length of the body. The number of spinules on the outer margin was more than that of the female. The deep anal sinus was 1/4 of the length of abdomen. The anal papillae were placed near the posterior end of the sinus.

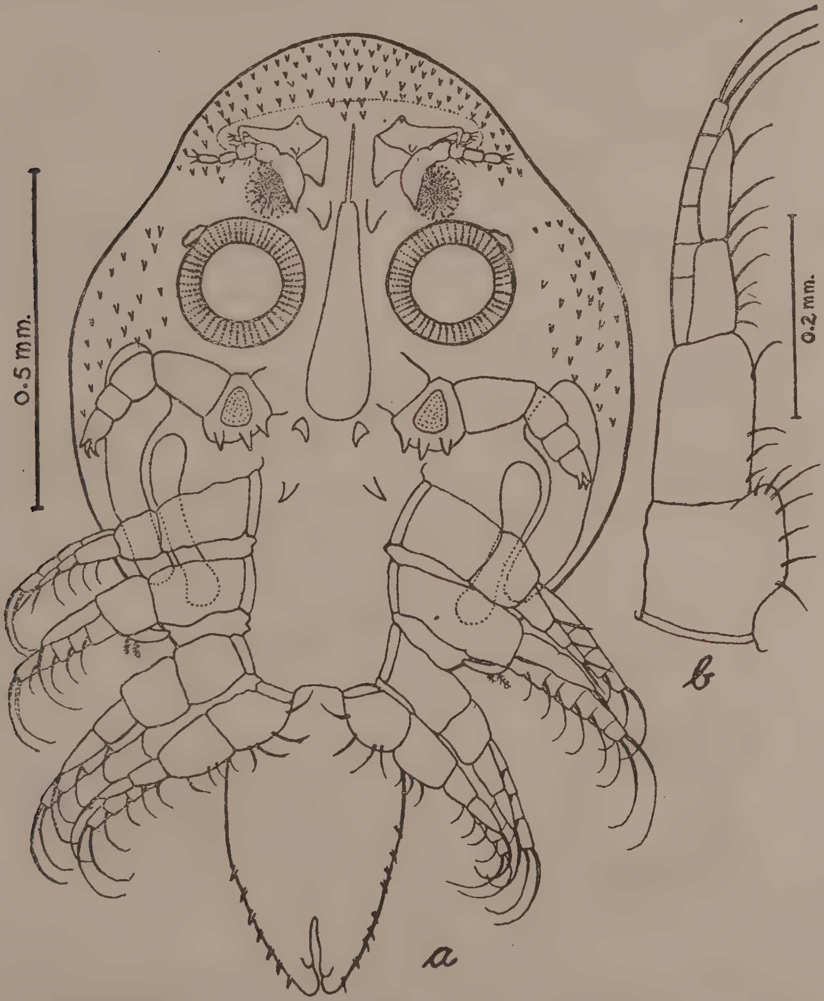

FIG. 5. *Argulus puthenveliensis.*

(a) 9 days old male larva, ventral view ; (b) Last leg of 10 days old larva, ventral view.

At the age of 9 days and 12 hours the male young one had developed a cleft on the posterior surface of the third leg between the coxa and the basis which later became the socket of the adult. At the same time, the rudiment of the peg of the adult also originated in the form of a small prominence on the anterior surface of the basis of the last thoracic leg. In this stage the rib of the suction cup had a long piece and four smaller pieces.

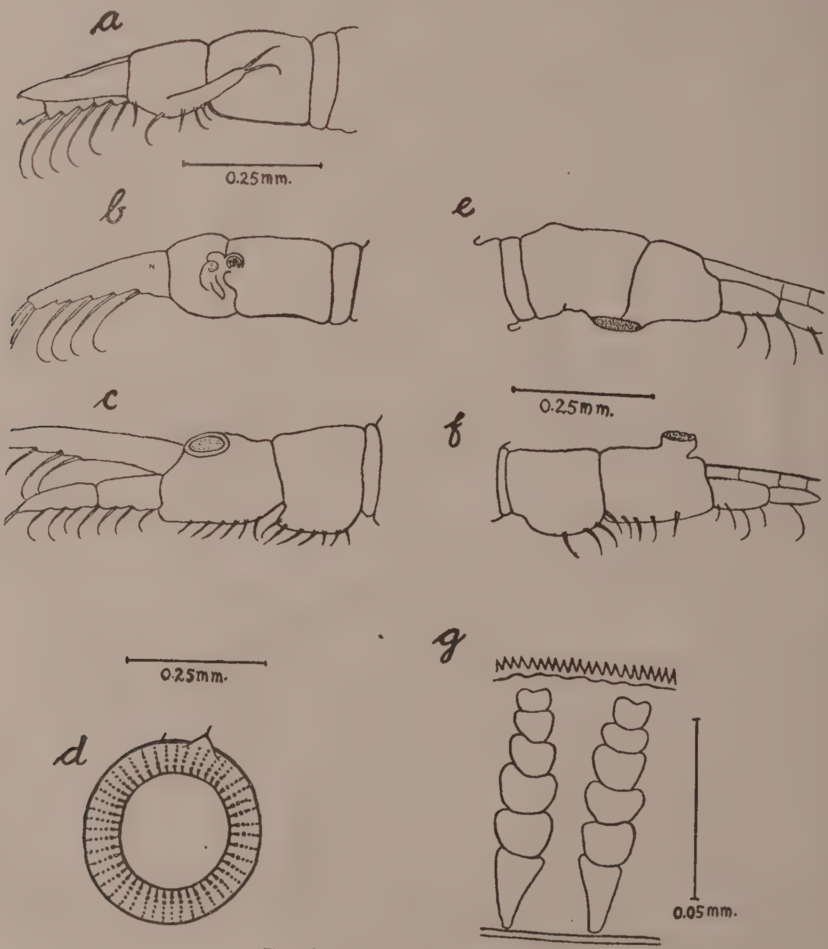

FIG. 6. *Argulus puthenveliensis.*

(a) Second leg of 12 days old larva showing fully formed flagellum, dorsal view; (b) Third leg of 12 days old male larva showing the socket with the folds, posterior view; (c) Fourth leg of 12 days old larva showing the peg; (d) Suction cup of 12 days and 12 hours old larva with highly reduced residuum; (e) Third leg of 12 days and 12 hours old male larva showing the socket, lateral view; (f) Fourth leg of the same larva with fully developed peg; (g) Rib of suction cup of the adult.

In the subsequent stages the median and lateral folds of the socket were developed and the peg assumed the adult nature. The flagella of the first two pairs of legs were in the form of long, finger-shaped processes with a pair of long setae at their tips unlike the whip-like flagella of *A. americanus* Meehean (1940). The residuum of the first maxilla became very much reduced in size. By the twelfth day it became a mere projection with a small spinule at its tip. On the thirteenth day after hatching the residuum completely disappeared and the parasite attained the mature stage.

The two pairs of respiratory areas remained in more or less the same shape throughout the development. The anterior one was club-shaped and curved around the posterior one which was dumb-bell shaped. The respiratory areas of *A. puthenveliensis* resembled those of *A. siamensis* Wilson in the general shape and the orientation of the two areas ; in *A. puthenveliensis* they were slightly broader than those of *A. siamensis*. The number of the ribs of the suction cups varied from 38 to 49 in different individuals, irrespective of the stages. It was interesting to note that none of the larvae had the same number of supporting ribs in both the suction cups.

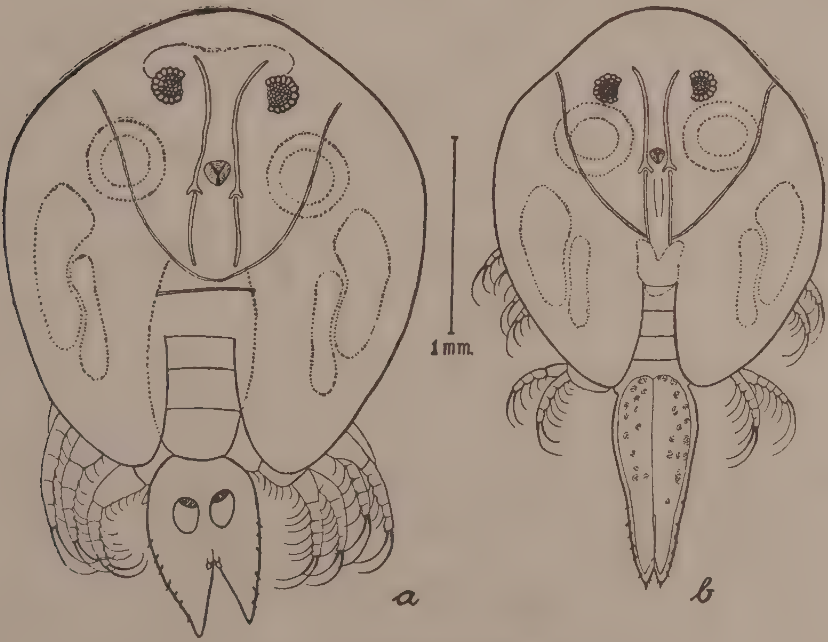

FIG. 7. *Argulus puthenveliensis.*

(*a*) Adult female, dorsal view ; (*b*) Adult male, dorsal view.

During the study of the development the successive moultings could not be followed and hence not referred to in the present paper. It was observed that for every eleven female young ones there were six to seven males. After attaining maturity they started reproducing themselves within a week's time.

SUMMARY

Argulus puthenveliensis Ramakrishna was found infesting the freshwater fishes of Udayamperoor, Kerala State. Its behaviour was observed, especially the method of attachment to the host, copulation and egg-laying. The fertilized eggs laid in masses were allowed to continue the development. They hatched out after 13 days and 21 hours and the newly hatched larvae were very active. They were allowed to get attached to small fishes and the post-embryonic development was studied in detail until the young ones reached maturity. They started reproducing themselves within a week.

ACKNOWLEDGEMENTS

I wish to express my deep indebtedness to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for his kind encouragement and valuable advice. My sincere thanks are due to Rev. Dr. Theobald, Principal and head of the Department of Zoology, Sacred Heart College, Ernakulam, South India, for allowing me to do the work in his department.

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ON THE EARLY LARVAL STAGES OF TWO LEUCOSIID CRABS, *PHILYRA CORALLICOLA* ALCOCK AND *ARCANIA SEPTEMSPINOSA* (FABRICIUS)

By K. N. Sankolli

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In the family Leucosiidae, studies have been made on the larval stages of *Philyra pisum* (Aikawa, 1929), *P. scabriuscula* (Menon, 1937 ; Raja Bai, 1960), *P. globosa* (Chhapgar, 1958) and *Ixa cylindrus* (Raja Bai, 1960) but so far no work has been done on the larval stages of *P. corallicola* and *Arcania septemspinosa*.

A live berried specimen of *P. corallicola* was collected from the Mirya sandy beach and that of *A. septemspinosa* was obtained from the trawl-catches at a depth of 22 fathoms, both off Ratnagiri. Laboratory hatchings of the eggs were obtained by keeping each species separately in aquarium tanks with sea water. The larvae survived in the laboratory for about 48 hours only.

Philyra corallicola Alcock

First zoaea (Text Fig. 1).

Measurements : Body length = 1.95 mm.
Eye width = 0.20 mm.
Body width = 0.41 mm.
Dorsal spine = 0.68 mm.
Rostral spine = 0.79 mm.

The carapace is rounded and is without any trace of lateral spines. The rostral spine is slightly longer than the dorsal spine and both are slightly curved. Melanophores are present on the basal segment of the maxillipeds, and on the abdominal segments where they are arranged in transverse bands. The rostral and dorsal spines have a tinge of light orange on the inner margin and there is a melanophore near the middle of the carapace just below the cardiac region. Except for these chromatophores, the body is more or less colourless.

The antennular peduncle is unsegmented with three aesthetes, of which one is about half the length of the remaining two (Fig. 1, b).

The antenna is represented by a rudimentary stump tapering distally to a point (Fig. 1, c.). The distal end bears a few minute spine-like processes which are discernible only under high magnification.

The mandible is roughly bilobed with the cutting edge minutely serrated (Fig. 1, d). There is no palp.

The maxilla consists of an unsegmented endopodite with three terminal setae of almost equal length and two endites, each bearing five hirsute setae (Fig. 1, e).

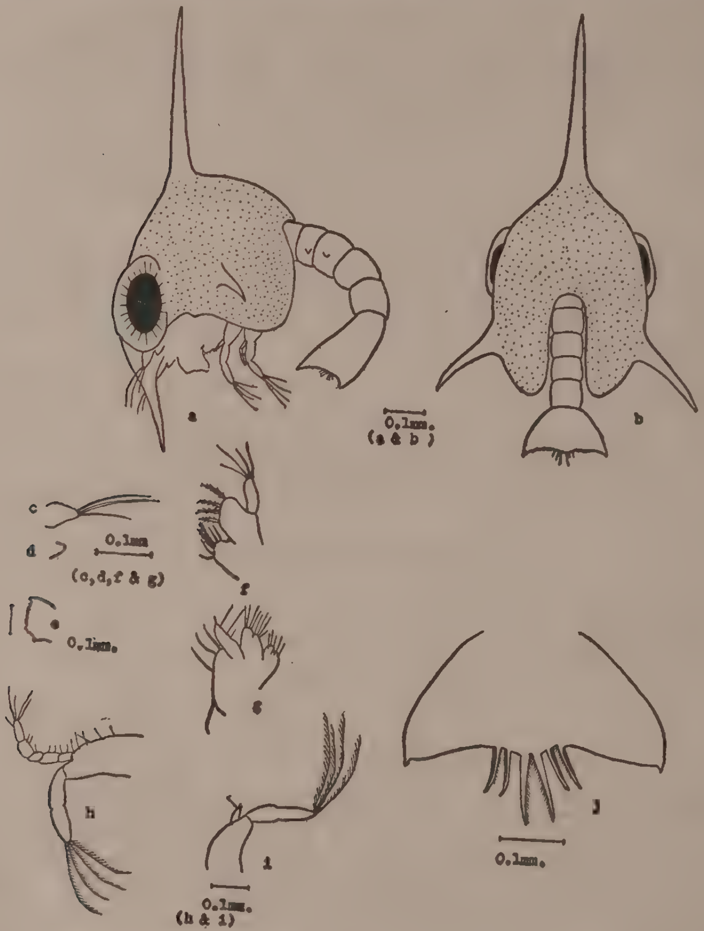

FIG. 1. *Philyra corallicola* Alcock, First Zoaea. (*a*) Lateral view of zoaea. (*b*) Antennule. (*c*) Antenna. (*d*) Mandible. (*e*) First maxilla. (*f*) Second maxilla. (*g*) First maxilliped. (*h*) Second maxilliped. (*i*) Telson.

The coxopodite of the second maxilla has five setae and the basipodite has eight. The endopodite is unsegmented and has a marginal notch from where the proximal seta arises. Distally it has two setae. The scaphognathite tapers to a point and has three plumose marginal setae (Fig. 1, f.)

The base of the first maxilliped is stout and broad and the two-segmented exopodite bears four plumose setae. The endopodite is five-segmented. The distal segment bears four rather short setae and each of the four remaining segments bears a pair of setae (Fig. 1, g).

In the second maxilliped the endopodite is small and unsegmented, bearing two small setae terminally and one relatively long seta on the inner side. Apart from this, there is no other marked difference between the first and second maxillipeds (Fig. 1, h).

The first two pairs of pereiopods are represented by biramous rudimentary buds.

The abdomen consists of five free segments, followed by a fused telson and sixth segment. The second and third segments each bears a pair of hook-like lateral projections.

The telson is flat and roughly triangular in shape with six setae in the middle and a lateral spine on either side of the posterior margin. The central seta is plumose almost to the tip. More than the basal three-fourths of the remaining two setae is plumose. On each postero-lateral corner, there are two minute spine-like swellings, of which the posterior is rather more pronounced (Fig. 1, i).

In the first zoaea of the four species, *scabriuscula*, *pisum*, *globosa* and *corallicola* of the genus *Philyra* so far described, the rostrum is short in *pisum* and is long in the remaining three species ; only in *globosa* the antenna is a rudimentary stump without any aesthetes or spines ; all the four species have three pairs of median setae on the posterior margin of the telson, but in *globosa* and *corallicola* the median setae are provided with prickles and these are restricted to basal half in *globosa*, whereas in *corallicola* they extend nearly to tip.

Arcania septemspinosa (Fabricius)

First zoaea (Text fig. 2).

Measurements : Body length = 1.39 mm.
Eye width = 0.17 mm.
Body width = 0.38 mm.
Dorsal spine = 0.35 mm.
Rostral spine= 0.29 mm.

The carapace is minutely punctate and is more or less rounded. The dorsal spine is longer than the rostral spine and the lateral spines are situated far below the middle of the carapace. There is a narrow longitudinal slit in the posterior part of the carapace from which the abdomen emerges.

The larva is almost colourless except for the mandibles which are violet-red and for a slight yellow colouration in the vicinity of maxillipeds.

The antennule is represented by a small unsegmented peduncle with three non-plumose aesthetes (Fig. 2, c).

The antenna is a minute unsegmented stump without any aesthetes (Fig. 2, d).

The mandible is feebly developed and the cutting edge is minutely serrated. There is no palp (Fig. 2. e).

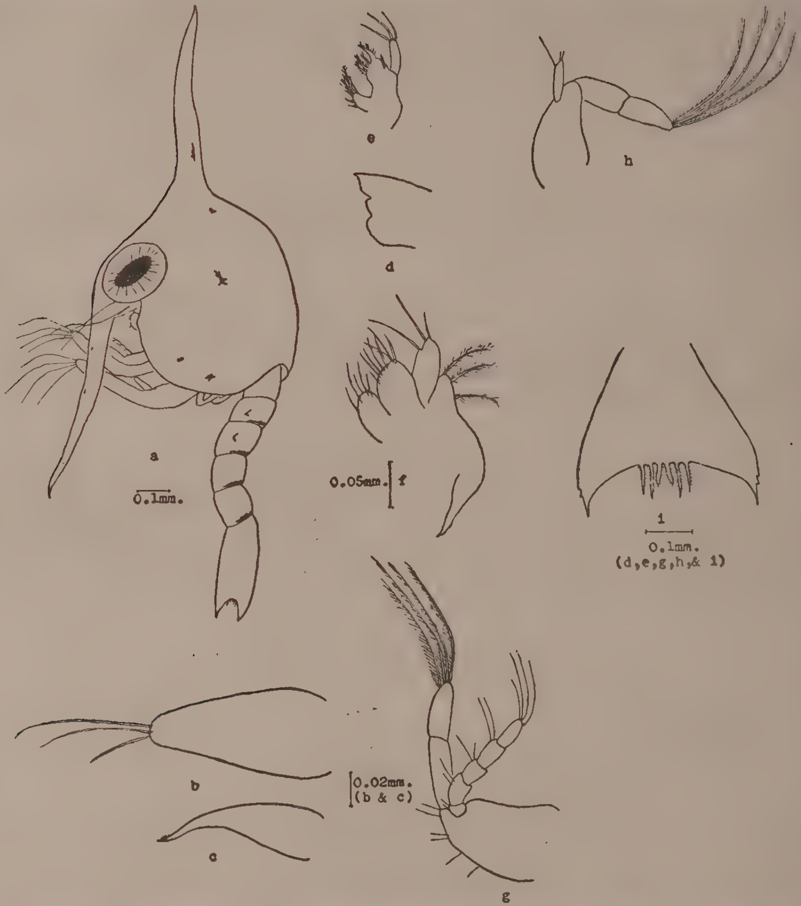

FIG. 2. *Arcania septemspinosa* (Fabricius), First Zoaea. (*a*) Lateral view of zoaea. (*b*) Posterior view of zoaea. (*c*) Antennule. (*d*) Antenna. (*e*) Mandible. (*f*) First maxilla. (*g*) Second maxilla. (*h*) First maxilliped. (*i*) Second maxilliped. (*j*) Telson.

In the first maxilla the coxopodite bears six setae of which the middle two are plumose. The basipodite bears four plumose setae and the non-segmented endopodite bears four terminal setae (Fig. 2, f).

In the second maxilla both the basipodite and coxopodite are partially bilobed bearing 5 setae on basi- and 8 setae on coxopodites respectively. The endopodite is unsegmented with one terminal and three marginal setae. The scaphognathite has four setae on its outer margin (Fig. 2, g).

In the first maxilliped the exopodite is imperfectly two-segmented bearing four terminal plumose setae. The five-segmented endopodite bears on the last segment four short terminal setae and a small delicate hair on the outer margin, one seta on the third segment and two setae on each of the remaining segments. There are about six setae on the basipodite (Fig. 2, h).

The second maxilliped does not differ much from the first except that the endopodite is minute, unsegmented, with one fairly long terminal seta on the inner side and two relatively small setae on the outer side (Fig. 2, i).

The abdomen consists of five segments and the telson is fused with the sixth segment. There is a more or less hook-like knob on each side of the second abdominal segment and a round knob on the third segment.

The telson is much broader than long and the posterior margin at the mid-region bears three pairs of setae. The middle pair has its inner margin plumose and outer margin naked. In the second pair the outer margin is minutely pectinate in the basal three-fourths and the inner margin bears no setae. The third pair is plumose on the inner side and is minutely pectinate on the outer margin, the remaining distal one-fourth bearing no setae on either side. The lateral spine on each side is very small. (Fig. 2, j).

SUMMARY

Early larval stages of *Philyra corallicola* Alcock and *Arcania septemspinosa* (Fabricius), as obtained from laboratory hatchings have been described.

ACKNOWLEDGEMENTS

I am grateful to Dr. C. V. Kulkarni, Director of Fisheries, Maharashtra State, and to Dr. H. G. Kewalramani, Research Officer, for helpful criticism. My sincere gratitude is also due to Shri M. R. Ranade, Curator, Marine Biological Research Station, Ratnagiri, for his constant guidance and encouragement during the course of the study.

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J. Mar. biol. Ass. India, 1961, **3** (1 & 2) : 92-95

ON A NEW GENUS OF PORCELLANIDAE (CRUSTACEA-ANOMURA) *

By C. SANKARANKUTTY
Central Marine Fisheries Research Institute, Mandapam Camp

The specimen described below was collected during one of the regular dredge operations near Manoli Island in the Gulf of Mannar at a depth of about 6 meters. Unfortunately this interesting form was not collected during the subsequent dredge operations, which may indicate its relative rarity.

PSEUDOPORCELLANELLA n.gen.

Description of the genus : Carapace longer than broad ; front trilobed ; cheliped short and stout ; multiunguiculate dactylus of ambulatory leg ; antenna reduced, its peduncle formed of three segments and flagellum consisting of few segments ; Carpus in cheliped reduced.

Genotype : Pseudoporcellanella manoliensis, deposited in the type collection of the Central Marine Fisheries Research Institute, Mandapam Camp.

Description of the species : Pseudoporcellanella manoliensis n.sp.

The specimen representing the genus has an elongated carapace (Fig. 1), the breadth of which is about 2/5 its length. The carapace is highly convex from side to side and its dorsal profile is straight. The dorsal surface of the carapace is traversed by transverse striae, which are more prominent towards the anterior end and the sides.

The front is trilobed, the median lobe of which is conical with a subacute tip and is much larger than the lateral lobes. The lateral lobes have their acute tips incurved. The borders of all the frontal lobes are unarmed. The outer orbital corner of the carapace has a triangular projection pointing antero-laterally, behind which the lateral borders of the carapace diverge upto about ¾ the length of the carapace, converging again. The posterior border of the carapace is concave.

The basal antennular joint (Fig. 5) is suboval in shape and has a flat ventral side, the antennular flagellum being attached on the inner side. The antenna is removed from the orbit and is located in a sinus surrounded by three pointed triangular projections (Fig. 4) ; the outer orbital projection forming the dorsal, the pterygostomial projection forming the ventral and a similar spiny projection anterior to the antenna forming partly the lower border of the eye-peduncle. The antennal peduncle is formed of three segments, the second being the largest and the antennal flagellum is composed of only five segments. In the dorsal view of the animal, a few distal segments of the antenna alone are visible.

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The ischium is the broadest segment of the external maxilliped (Fig. 2) and has a small lobe at the distal end of the outer side. The merus, when measured along the outer border, is the longest segment of the maxilliped.

The chelipeds are short, stout and subequal (Fig. 6 & 7). The merus when measured along the outer border is longer than the carpus. The carpus is a short segment and is slightly broader than long. The manus is flattened from side to side and is the largest segment in the cheliped, its length along the upper border is same as that of dactylus. The fingers are irregularly toothed along their cutting edges ; the tips of the fingers are hooked and cross each other, the tip of the dactylus lying inside the tip of the fixed finger. The ventral border of the manus from the proximal end to the tip of the fixed finger has a fringe of bipinnate hairs, the latter increasing in numbers towards the tip. The dorsal border of the dactylus also has a similar fringe of hairs and they are more concentrated at the tip.

The first three ambulatory legs (Fig. 3) are stout and of the same size. The merus is longer than the propodus, when measured along the outer border. The propodus has no spinule at the distal end of the ventral side. The dactylus is curved and carries three spinules, the middle one being the largest and the proximal one the smallest. The fourth leg is reduced as in the other porcellanids.

The abdomen consists of six segments, the second being the broadest. The telson is much longer than broad and has a central triangular plate on either side of which is a transverse division.

The ground colouration of the animal is milky white with transverse brownish bands on the carapace and the chelipeds. The carapace has two transverse bands near the anterior end, the first is larger than the second and runs between the orbits, and the second band immediately follows the first. The merus and the carpus of the cheliped have one transverse band each ; whereas the manus has two, the distal band widening towards the outer border of the segment. These bands are seen to disappear quickly on preservation.

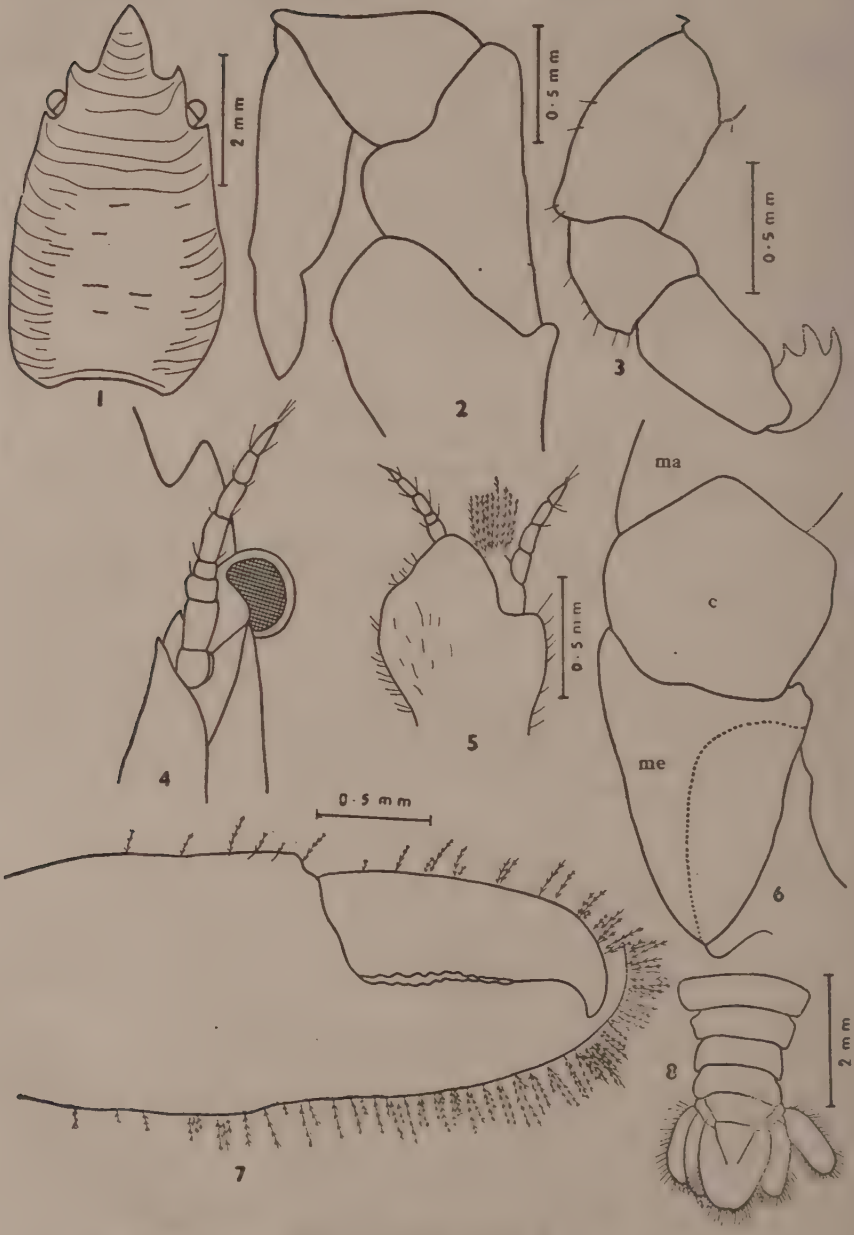
Measurements in millimeters :

Length of carapace ..	5.60
Breadth of carapace ..	2.86
Length of manus of cheliped ..	2.46
Breadth of manus of cheliped ..	1.00
Length of dactylus of cheliped ..	1.06
Breadth of carpus of cheliped ..	1.00
Length of carpus of cheliped ..	0.66
Length of merus of ambulatory leg ..	1.00
Breadth of merus of ambulatory leg ..	0.60

Holotype : A single immature specimen represents the holotype.

Locality : Gulf of Mannar at about 6 metres depth near Manoli Island.

Affinities : The characteristically reduced fourth ambulatory leg places this form in the tribe Galatheidea. The species, in having an abdomen closely pressed to the thorax and in the shape of the external maxilliped, shows its close affinity to the genera of the family Porcellanidae. The elongated carapace, trilobed front



PSEUDOPORCELLANELLA

1. Dorsal surface of carapace; 2. External maxilliped; 3. Ambulatory leg; 4. Antenna *in situ*. 5. Basal antennular segment; 6. Dorsal surface of cheliped showing ischium, merus (me), carpus (c), and proximal end of manus (ma); 7. Inner side of chela; 8. Abdomen.

and the triunguiculate dactylus of the ambulatory leg indicate its resemblance to the genus *Porcellanella* White.

However, because of the reduced antennal flagellum (the only other genus with reduced antennal flagellum is *Minyocerus* Stimpson) and the reduced carpus of cheliped, the specimen comes closer to the true crabs. Hence it is proposed to designate this lone specimen as *Pseudoporcellanella manoliensis*. Gen. *et*. sp. nov. When sufficient material of this interesting form becomes available, perhaps it will be possible to elucidate its exact systematic position.

SUMMARY

A new genus *Pseudoporcellanella* (Family-Porcellanidae) has been created to accommodate a new species *P. manoliensis*. The description of the new genus and species has been given and its affinities have been discussed.

ACKNOWLEDGEMENTS

I wish to express my grateful thanks to Dr. Jones, Director, Central Marine Fisheries Research Institute, for his guidance and encouragements during my work. I am also indebted to Dr. Janet Haig of the Allan Hancock Foundation for confirming my identification and for her valuable suggestions. I also wish to express my thanks to Dr. R. Raghu Prasad for kindly going through the manuscript and offering valuable suggestions. My thanks are also due to Dr. R. P. Varma, Dr. E. G. Silas and Shri P. R. S. Tampi for constructive criticisms.

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J. Mar. biol. Ass. India, 1961, 3 (1 & 2): 96-100

ON THE PORCELLANID CRAB, *PORCELLANELLA TRILOBA* WHITE (CRUSTACEA-ANOMURA), A COMMENSAL ON SEA PEN; WITH REMARKS ON ALLIED SPECIES[1]

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Recently, in a note on animal association, Jones (1959) recorded a porcellanid crab on the sea pen *Pteroeides esperi* Herklots, commonly occurring in the Gulf of Mannar. The porcellanid crab was passed on to me for identification, which I identify here as *Porcellanella triloba* White.

Porcellanella (Porcellanidae-Anormura) was recorded for the first time in 1852 during the voyage of H.M.S. ' Rattlesnake ' by White, who designated it by the species *P. triloba* from Cape Capricon, Australia. Subsequently Stimpson (1858) described another species *P. picta* from Hong Kong. In addition, *P. triloba* has also been recorded from Celebes Sea, Falkland Island and Rameswaram by Henderson and from Zanzibar by Barnard (1950). Miyake (1942, 1943) described *Porcellanella picta* and *P. triloba* from Bingo-Nanda and Palau Island respectively.

PORCELLANELLA TRILOBA WHITE

Porcellanella triloba, White, 1852, pp. 394-395, Fig. 2, 2a.

Porcellanella picta, Stimpson, 1858, pp. 243-244.

Porcellanella triloba, Haswell, William, 1882, p. 149.

Porcellanella triloba, Henderson, 1888, pp. 112-113.

Porcellanella triloba, Henderson, 1893, p. 429.

Porcellanella triloba, Barnard, 1950, p. 891.

Porcellanella picta, Miyake, 1943, pp. 134-137, Figs. 54, 55 A-F.

Material : Six mature specimens of which four are females and the rest males.

Locality : Vedalai, in Gulf of Mannar ; Often caught in shore seines along with the host, *Pteroeides esperi* Herklots.

Description : The carapace is longer than broad and slightly convex from side to side. The dorsal profile of the carapace rises behind the frontal lobes and runs more or less straight to the posterior end. The dorsal surface of carapace has transverse striae, clearer towards the anterior end and sides. Front is trilobed, the median lobe being longer and broader but subacute as the lateral lobes. The borders of all the lobes appear smooth, but minutely serrated under magnification. The median frontal lobe has a fringe of minute hairs pointing laterally, all of them arising in a line just below the border of the lobe. The ventral keel of the median lobe originates from the base and runs up to 2/3 the length of the lobe. The inner border of the lateral lobe is almost straight whereas its outer border is rounded. The margin of the carapace overlying the eye peduncle and antenna is concave. The carapace is widest a little behind the insertion of the antenna, from whence it narrows posteriorly. The posterior border of the carapace is concave.

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The basal antennular joint (Fig. 10) is lobular and has a flat ventral side and carries two teeth at the inner distal margin, the inner of the two being smaller. The spiny triangular lobe located just in front of the insertion of the antenna covers only a part of the ventral side of the eye peduncle. Below this spiny projection is a small and blunt projection of pterygostomial region, with a cleft between the two. The pterygostomial region also possesses striation. The antennal peduncle consists of three enlarged segments of which the second is largest and third the shortest. The first segment is free from the margin of the carapace and visible in the dorsal view of the animal. The antennal flagellum is composed of numerous segments.

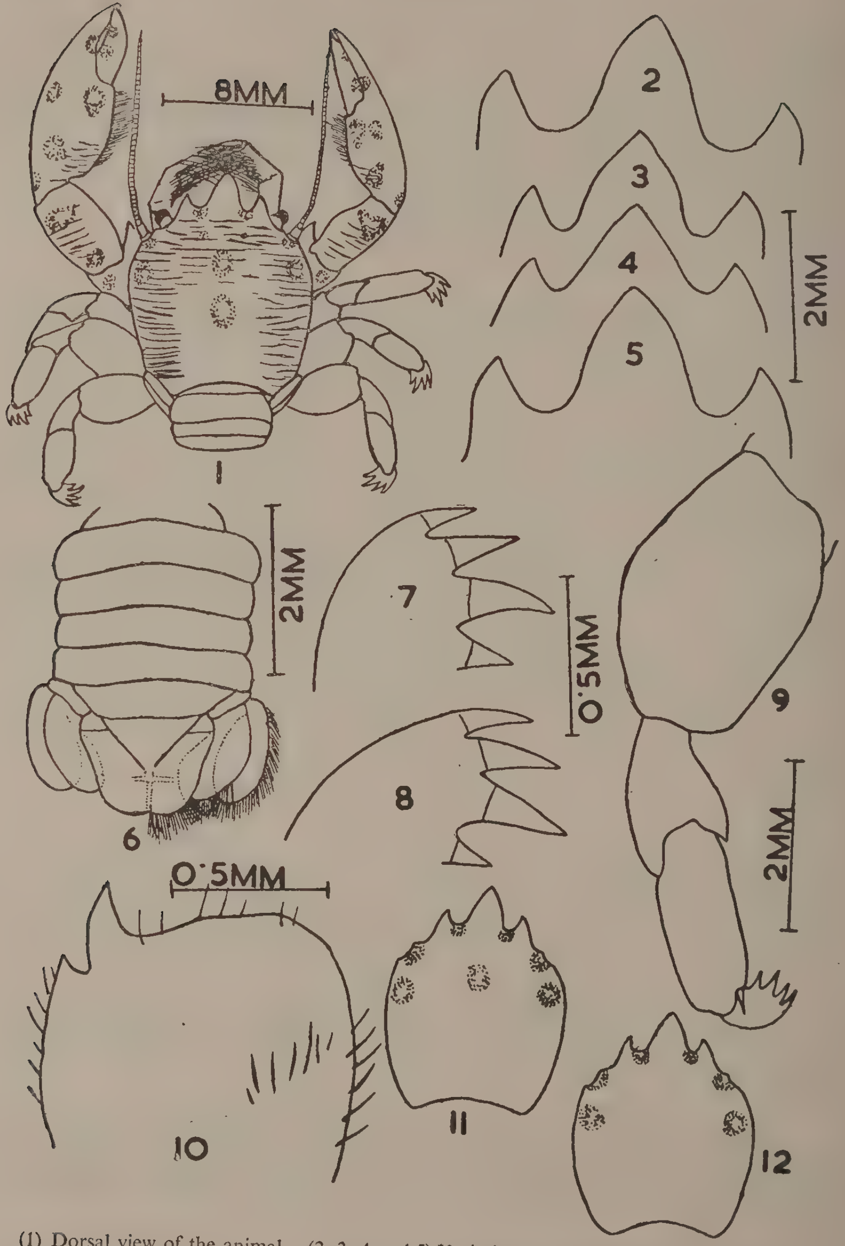
The chelipeds are unequal, either the left or the right being larger. The inner distal corner of ischium as well as merus are produced into triangular lobes, the lobe on the merus is the larger. The carpus is longer than broad and has a longitudinal groove on its inner side. Manus is a flattened segment with a keeled outer border, and its length including the fixed finger approximates the length of carapace. Manus is broadest midway between its base on the outer side and the proximal end of dactylus. On the inner side of the manus is a thick fringe of plumose hair, originating at the broadest part of the manus and ending in between the fingers. The fingers have flat cutting edges, the outer side forming a raised feebly toothed cutting edge. The tips of the fingers are hooked and cross each other. The carpus and manus are clearly striated on the dorsal side, less distinct on the manus.

The first three ambulatory legs (Fig. 9) are of the same size, the merus is longer than broad (high) and flattened from side to side. The carpus and propodus when measured along the outer side appear to be of same length. The borders of all the segments are smooth. There are two spinules at the distal end on the ventral side of the propodus. The dactylus (Fig. 7, 8) is curved and carries four spinules, of which second is the largest. The fourth leg is characteristically reduced.

The ischium of the external maxilliped, at the distal end on the outer side has a triangular lobe. Propodus and carpus when measured along the outer border are equal in length. Merus, ischium and also the exopod have transverse striations on their outer side.

The abdomen (Fig. 6) consists of six segments and telson. Segments 2, 3, 4 and 5 are equal in breadth. Telson is broader than long and has a median triangular plate with a transverse division on either side. The distal end of telson and borders of uropod, excepting the proximal outer half of endopod, carry plumose bipinnate setae.

Colouration : The ground colouration of the animal in living condition is milky white, turning slightly brownish on preservation. The carapace as well as



(1) Dorsal view of the animal. (2, 3, 4 and 5) Variations in the shape of frontal lobes. (6) Abdomen. (7 and 8) Dactylus of walking legs. (9) Walking leg. (10) Basal antennular segment. (11 and 12) Variation in the colouration of carapace.

chelipeds have varying number of blotches, most of them being symmetrically arranged, with a few median blotches on the carapace. The carapace basically has the following blotches. A blotch is located between the median and lateral frontal lobes near the border. Another blotch is seen on the supra-antennal margin of the carapace and a similar one immediately behind. The carapace may have one or two median blotches. A few of the variations are shown in the figures (Figs. 1, 11 and 12). These blotches in fresh specimens are black in colour with a lighter centre, and quickly disappear on preservation. In a single specimen a blotch is seen at the base of the pterygostomial spine also. In still another specimen, merus, carpus and propodus of external maxilliped has a single blotch each.

Measurements (in millimeters) of a male and a female specimen :

		Female	*Male*
Length of carapace including median frontal lobe	..	12.0	10.0
Greatest breadth of carapace	..	8.5	7.5
Interorbital breadth	..	4.0	4.0
Length of median frontal lobe	..	1.5	1.2
Breadth of median frontal lobe	..	1.4	1.3
Length of lateral frontal lobe	..	0.7	0.6
Breadth of lateral frontal lobe	..	0.6	0.6
Length of carpus of cheliped along the outer border	..	5.0	5.0
Breadth of carpus of cheliped	..	3.0	3.5
Length of manus of cheliped with fixed finger along the outer border		12.0	12.0
Breadth of manus of cheliped	..	4.0	4.0
Length of dactylus of cheliped	..	4.5	4.0

Distribution : Cape Capricon in Australia (White) ; Celebes Sea, Falkland Island, Rameswaram (Henderson) ; Zanzibar (Barnard) ; Hong Kong sea (Stimpson) ; Inland sea, Bingo Nada, Tosa, Tomioka, Amakusa (Miyake).

Remarks : Specimens in my collection are in perfect agreement with the original description and figure of *P. triloba* given by White and also with the colouration of the carapace described by Henderson. Stimpson also noticed similar colouration in his species *P. picta.* Henderson, on comparing the original specimens of both the species remarks, ' In White's species the median frontal projection but slightly exceeds the lateral ones, and its apex is rounded, while the first or most proximal of the four spinules on the ambulatory dactyli is very small ; in Stimpson's species the median frontal tooth is slightly longer and subacute, and the four spinules on the dactyli are subequal. The two species may yet be united, but at present may be kept separate '.

A comparison of *P. triloba* and *P. picta* with specimens of the recent collection shows the following variations. In my material the median frontal lobe shows variation from subacute to rounded condition (Figs. 2, 3, 4 & 5). Further, figures 7 & 8 clearly indicate the size variation of the most proximal spinule of the dactylus of the ambulatory legs. Hence the differentiation of *P. triloba* and *P. picta* based on the above characters does not seem to be tenable whereas these characters can be considered to be individual variations. As originally suggested by Henderson and also in the light of above observations, it is proposed to relegate *P. picta* Stimpson to the synonymy of *P. triloba* White.

Miyake (1942) described *P. triloba* from Palau Island off Malagal Island, and has also figured the specimen. His figures, on comparing with the original figure given by White, shows some important differences. (1) The frontal lobes are very rounded. (2) The carapace is narrower. But the species *P. picta* described by him agrees in all respects with the specimens of my collection especially in the nature of basal antennular segment, nature of the front and size of the spinules on the dactylus. Hence I feel that *P. picta* described by him is actually *P. triloba* White while his *P. triloba* represents a species new to science.

SUMMARY

Porcellanella triloba White which is a common porcellanid crab commensal on the sea pen *Pteroeides esperi* Herklots has been redescribed in this paper. *Porcellanella picta* Stimpson is here considered as a synonym of *P. triloba* White and reasons have been given for doing so.

ACKNOWLEDGEMENTS

I wish to express my grateful thanks to Dr. S. Jones, Director, Central Marine Fisheries Research Institute for his guidance and encouragement. I am also thankful to Dr. Janet Haig of the Allan Hancock Foundation for going through the manuscript and offering valuable suggestions. I am indebted to Dr. R. P. Varma, Dr. E. G. Silas and Shri P. R. S. Tampi for constructive criticism.

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ON DECAPODA BRACHYURA FROM THE ANDAMAN AND NICOBAR ISLANDS

1. FAMILIES PORTUNIDAE, OCYPODIDAE, GRAPSIDAE AND MICTYRIDAE.*

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INTRODUCTION

The present paper begins a series on the brachyuran fauna of the Andaman and Nicobar Islands, and describes 29 species and a variety collected during February to March 1960 from (1) Localities around Port Blair, viz. Bimbletan, South Point, Corbins Cove, Aberdeen Bay, Phoenix Bay, North Bay and Kalapahad ; (2) Neill Island ; (3) Car Nicobar ; (4) Maya Bandar ; (5) Long Island ; and (6) Nancauri. Of these reported in this account, 8 species and 1 variety are recorded for the first time from this region.

Heller (1868) recorded 27 species of crabs belonging to the three families Portunidae, Ocypodidae, and Grapsidae. Alcock (1899 & 1900) in his ' Materials for a Carcinological Fauna of India ' described 35 species of portunids, 13 species of ocypodids and 24 species of grapsoids from the Andaman and Nicobar Islands, apart from *Mictyris longicarpus* Latreille. Later de Man (1908-09) reported *Sesarma thelxionae* de Man ; Kemp (1919) *Macrophthalmus pacificus* Dana (=*M. bicarinatus* Heller) and *Dotilla wichmanni* de Man and Chopra (1931) *Lissocarcinus ornatus* Chopra from the same region.

The collections were made mainly from the coral reefs and the intertidal region, vast areas of which get exposed during the ebb tide. A number of specimens were collected from the submerged reef with the help of a mask and snorkel. Portunids were mainly collected with a small dredge operated at 10 metres in the Aberdeen Bay, Port Blair.

In this paper only those works dealing with the fauna of Indian region and a few of the outstanding works are referred to.

The following is the list of species described in this paper. The asterisk mark denotes new record for the Andaman and Nicobar Islands.

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Family PORTUNIDAE

1. *Portunus sanguinolentus* (Forskal).
2. *P. granulatus* (Milne Edwards).
*3. *P. pelagicus* (Linnaeus)
*4. *P. minutus* (Shen).
*5. *P. emarginatus* Stephenson & Campbell.
6. *Scylla serrata* (Forskal).
7. *Thalamita crenata* (latreille).
8. *T. prymna* (Herbst).
9. *T. chaptali* (Audouin & Savigny).
10. *T. admete* (Herbst).
11. *T. integra* Dana.
*12. *Charybdis* (*Goniohellenus*) *truncata* (Fabr.).

Family GRAPSIDAE

13. *Grapsus albolineatus* Lamarck.
*14. *Metopograpsus frontalis* Miers.
*15. *Pachygrapsus minutus* Milne Edwards.
*16. *P. planifrons* de Man.
*17. *Ptychognathus dentatus* de Man.
18. *Sesarma* (*Chiromantes*) *bidens* (De Haan).
19. *Metaplax distincta* Milne Edwards.
*20. *Plagusia depressa* var. *immaculata* Lamarck.
21. *Percnon planissimum* (Herbst).

Family OCYPODIDAE

22. *Ocypoda ceratophthalma* (Pallas).
23. *O. cordimana* Desm.
24. *Uca marionis excisa* Nobili.
25. *U. annulipes* (Latreille).
26. *Dotilla mictyroides* (Milne Edwards).
27. *D. wichmanni* de Man.
28. *Macrophthalmus convexus* Stimpson.
29. *Macrophthalmus telescopicus* (Owen).

Family MICTYRIDAE

30. *Mictyris longicarpus* Latreille.

Family PORTUNIDAE

Portunus minutus (Shen)

Neptunus (*Lupocycloporus*) *minutus*, Shen, 1937, p. 115.
Portunus minutus, Stephenson and Campbell, 1959, p. 89.
Material : One female 10 mm. broad and 6 mm. long.
Locality : Dredged from Aberdeen Bay.

Remarks : The ventral distal part of the merus of the cheliped has a spinule, the carpus carries three longitudinal ridges, the outer ridge joins the outer spine while the inner bifurcates in the middle and its inner branch joins the inner spine, the outer branch runs straight to the distal end of the joint.

Distribution : Singapore (Shen). This is the first record of the species from Andaman and Nicobar Islands.

Portunus emarginatus Stephenson and Campbell

Portunus emarginatus, Stephenson and Campbell, 1959, p. 107.

Material : Twelve males and seven females. The smallest ovigerous female 12 mm. broad.

Locality : Dredged from Aberdeen Bay.

Remarks : The specimens agree in all respects with the description given by Stephenson and Campbell except that they possess in addition a spinule at the distal end on the ventral side of the merus of the cheliped.

Distribution : Darnley Island, Queensland (Stephenson and Campbell) ; This is the first record of the species outside Australia.

Portunus sanguinolentus (Forskal)

Neptunus sanguinolentus, Heller, 1868, p. 26.
Alcock, 1899, p. 32.
Chopra, 1935, p. 475.
Pillai, 1951, p. 21.

Neptunus (Neptunus) sanguinolentus, Laurie, 1906, p. 412.
Chhapghar, 1957, p. 417.

Portunus sanguinolentus, Stephenson and Campbell, 1959, p. 98.

Material : Two specimens, one male and one female.

Locality : North Bay, Caught in stake nets.

Remarks : Even in the live condition the three characteristic blood red blotches on the posterior region of the carapace were faint.

Distribution : Nicobar (Heller) ; east and west coast of Indian Peninsula (Alcock) ; Travancore (Pillai) ; Bombay (Chhapghar). Outside India the species is known from East Africa to Hawaii.

Portunus pelagicus (Linnaeus)

Neptunus pelagicus, Alcock, 1899, p. 34.
Gravely, 1927, p. 142.
Pillai, 1951, p. 21.

Neptunus (Neptunus) pelagicus, Laurie, 1906, p. 412.
Chopra, 1935, p. 476.
Chhapghar, 1957, p. 418.

Portunus pelagicus, Stephenson and Campbell, 1959, p. 96.

Material : One male specimen 44 mm. long and 102 mm. broad.

Locality : North Bay ; caught in stake nets.

Distribution : Coasts of India (Alcock) ; Gulf of Mannar (Gravely) ; Travancore (Pillai) ; Bombay (Chhapghar).

The species is known from East Africa to Japan and Philippines.

Portunus granulatus (Milne Edwards)

Neptunus (Achelous) granulatus, Alcock, 1899, p. 45.
Borradaile, 1903, p. 208.
Laurie, 1906, p. 416.

Portunus granulatus, Stephenson and Campbell, 1959, p. 108.

Material : One male, one female and a juvenile, the former 18 mm. long and 27 mm. broad.

Locality : Male specimen from Car Nicobar, others dredged from Aberdeen Bay.

Remarks : In the juvenile specimen the anteroexternal angle of merus of the external maxilliped is less pronounced.

Distribution : Andaman, Nicobar Islands, Malabar Coast (Alcock). The species is known from Red Sea, Mauritius, up to Hawaii and Fiji.

Scylla serrata (Forskal)

Scylla serrata, Heller, 1868, p. 27.
Alcock, 1899, p. 27.
Leene, 1938, p. 14.
Pillai, 1951, p. 21.
Chhapghar, 1957, p. 416.
Stephenson and Campbell, 1960, p. 111.

Material : A male 51 mm. long and 75 mm. broad and a juvenile 13 mm. long and 19.5 mm. broad.

Locality : The large specimen was caught in a stake net in North Bay and the juvenile from Ross Island.

Remarks : The frontal lobes in the juvenile are low.

Distribution : Very extensive in the Indo-Pacific region ; from East Africa and Red Sea to Japan, Tahiti and New Zealand (Chhapghar).

Thalamita integra Dana

Thalamita integra, Henderson, 1893, p. 373.
Alcock, 1899, p. 85.
Laurie, 1906, p. 420.
Stephenson and Hudson, 1957, p. 339.

Material : A single male 11.5 mm. long and 18 mm. broad.

Locality : Dredged from Aberdeen Bay.

Distribution : Andamans (Alcock) ; Rameswaram, Tuticorin (Henderson); Gulf of Mannar off Ceylon (Laurie). Outside India the species is known from East Africa and Red Sea to Fiji.

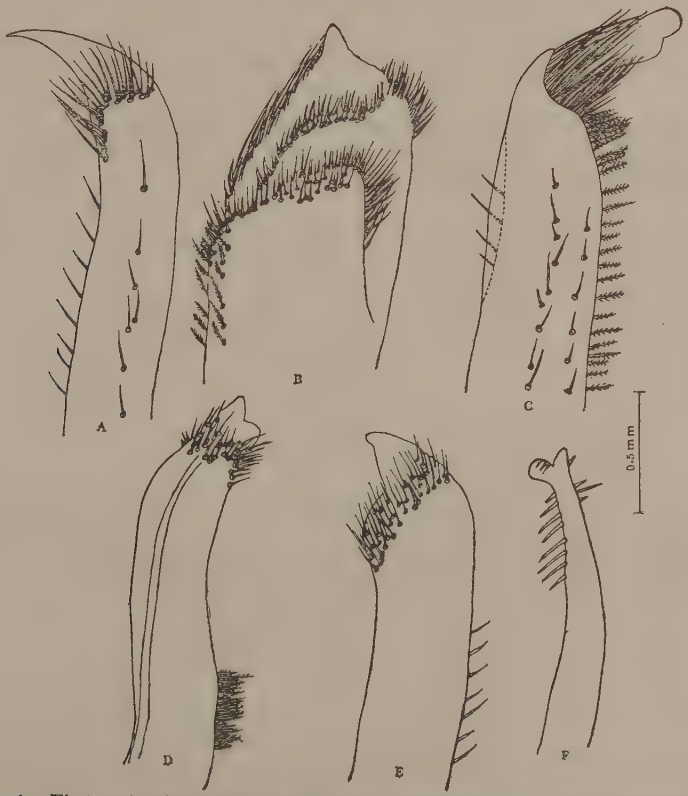

Fig. 1. First male pleopods of (A) *Mictyris longicarpus* ; (B) *Macrophthalmus convexus* ; (C) *Sesarma* (*Chiromantes*) *bidens* ; (D) *Dotilla wichmanni* ; (E) *Metaplax distincta* ; (F) *Thalamita admete*.

Thalamita admete (Herbst)

Thalamita admete, Heller, 1868, p. 28.
Stephenson and Hudson, 1957, p. 320.

Thalamita admeta, Alcock, 1899, p. 82.
Laurie, 1906, p. 420.

Thalamita admeta, var. *A. admeta*, Borradaile, 1903, p. 202.
var. *B. edwardsi*, Borradaile, 1903, p. 202.
var. *C. savignyi*, Borradaile, 1903, p. 202.
var. *edwardsi*, Gravely, 1927, p. 142.

Material : Five ovigerous females, four non-ovigerous females and four males. The smallest ovigerous female is 7 mm. long and 11 mm. broad.

Locality : Car Nicobar and Aberdeen Bay (Dredge collection).

Remarks : Compared to the description given by Stephenson and Hudson, the number of bristles on the first male pleopod is small, obviously this is a variable character.

Distribution : Andamans, Palk Straits (Alcock) ; Krusadai Island in Gulf of Mannar (Gravely). Outside India the species is known from East Africa, Red Sea to Japan, Hawaii and Fiji (Stephenson and Hudson).

Thalamita chaptali (Audomin and Savigny)

Thalmita chaptali, Alcock, 1899, p. 80.
Laurie, 1906, p. 419.
Stephenson and Hudson, 1957, p. 327.

Material : An ovigerous female 5.5 mm. long and 8 mm. broad and three males.

Locality : Dredged from Aberdeen Bay.

Remarks : The ventral distal end of the merus of the cheliped carried a spinule.

Distribution : Andamans (Alcock) ; outside India the species is known from Red Sea, Gulf of Siam and Australia (Stephenson and Hudson).

Thalamita crenata (Latreille)

Thalamita crenata, Heller, 1868, p. 29.
Alcock, 1899, p. 76.
Kemp, 1915, p. 249.
Gravely, 1927, p. 142.
Chhapghar, 1957, p. 423.
Stephenson and Hudson, 1957, p. 332.

Thalamita prymna var. *crenata*, Laurie, 1906, 418.

Material : One female and a male, the male measures 17 mm. in length and 25 mm. in breadth.

Locality : Dredged from Aberdeen Bay.

Distribution : Nicobar (Heller) ; Andamans, Bombay (Alcock) ; Chilka Lake (Kemp), Gulf of Mannar—Krusadai Island (Gravely) ; Bombay (Chhapghar). The species is also known from South Africa and Red Sea to Australia, Japan and Society Island (Stephenson and Hudson).

Thalamita prymna (Herbst)

Thalamita prymna, Alcock, 1899, p. 78.
Borradaile, 1903, p. 201.
Gravely, 1927, p. 142.
Chhapghar, 1957, p. 424.
Stephenson and Hudson, 1957, p. 346.

Thalamita prymna var. *annectans*, Laurie, 1906, p. 418.

Material : One female and two males ; large male measuring 36 mm. in length and 55 mm. in breadth.

Locality : Dredged from Aberdeen Bay.

Distribution : Andamans, Nicobars, Madras (Alcock) ; Krusadai Island in Gulf of Mannar (Gravely) ; Bombay (Chhapghar) ; The species is also known from Deloga Bay and Red Sea in the west to Japan and Marshall Islands in the east (Stephenson and Hudson).

Charybdis (*Goniohellenus*) *truncata* (Fabr.)

Charybdis (*Goniohellenus*) *truncata*, Borradaile, 1903, p. 200.
Leene, 1938, p. 118.
Stephenson, Hudson and Campbell, 1957, p. 503.

Charybdis (*Goniohellenus*) *ornata*, Laurie, 1906, p. 418.

Material : A single ovigerous female 18 mm. long and 27 mm. broad.

Locality : Port Blair, Andamans.

Remarks : Compared to the description given by Leene the following differences were observed. Instead of a distinct transverse ridge, the cardiac region of the carapace shows a group of granules. The second patch of granules, Leene observed on the mesobranchial region could not be seen. The second antero-lateral tooth is conical, third and fourth exactly alike, fifth and sixth are of the same shape but the former is slightly smaller. In both chelipeds the dactylus exceeds the upper border of the propodus in length. The carpus of the third walking leg carries a minute spinule at the dorsal distal part. The single specimen in my collection shows certain characters hitherto not observed. The inner orbital lobe carries an oblique granulated ridge joining its corner. The merus of the cheliped carries a spinule on the distal border of its ventral side. The second and third abdominal segments have transverse carinae extending from side to side, that of the fourth segment is however shorter, not reaching the lateral borders.

Distribution : From Maldives to Japan and Australia. This is the first record of the species from Andaman and Nicobar Islands.

Family GRAPSIDAE

Grapsus albolineatus Lamarck

Grapsus strigosus, Heller, 1868, p. 47.
Henderson, 1893, p. 390.
Alcock, 1900, p. 393.
Chopra and Das, 1937, p. 425.
Barnard, 1950, p. 115.
Pillai, 1951, p. 34.
Chhapghar, 1957, p. 515.

Grapsus albolineatus, Banerjee, 1960, p. 147.

Material : One male 20.5 mm. broad and 18 mm. long.

Locality : Car Nicobar.

Distribution : Nicobar (Heller) ; Rameswaram, Tuticorin (Henderson) ; Baluchistan, Sind coast, Malabar coast, Ceylon, Coromandel coast, the Arakan and Tenaserim coast, Andaman and Nicobar (Alcock) ; Travancore (Pillai), Bombay (Chhapghar). The species is widely distributed throughout the Indo-Pacific region from the Red Sea and east coast of Africa to Japan, the Polynesian Islands and Hawaii (Banerjee).

Metopograpsus frontalis Miers

Metopograpsus frontalis, Banerjee, 1960, p. 182.

Material : One ovigerous female, one male and two juveniles.

Locality : Car Nicobar.

Remarks : The recent publication by Banerjee (1960) has clearly brought out the salient characters by which the present species can be distinguished from its closely related species *M. messor*. An examination of the specimens in the present collection showed that they all belonged to the species *M. frontalis*.

The two species of this genus so far known from this region are *M. messor* and *M. oceanicus*, while *M. frontalis* is a new record for this region. But it may be pointed out here that as indicated by Banerjee (*l.c.*) ; *M. messor* was often confused with *M. frontalis*. Hence in all probability Alcock's collection might have included *M. frontalis* also. Definite confirmation as to whether Alcock's collection had only *M. frontalis* or not can be ascertained only after a restudy of his specimens.

Distribution : Indo-West Pacific region, from Ceylon to the Pacific Ocean (Banerjee).

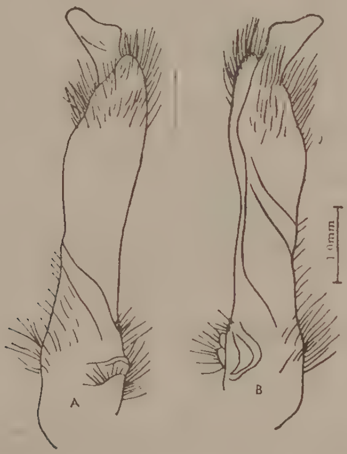

FIG. 2. First male pleopod of *Metopograpsus frontalis*. (A) dorsal view ; (B) ventral view.

Pachygrapsus minutus A. M. Edw.

Pachygrapsus minutus, Alcock, 1900, p. 399.
Borradaile, 1903, p. 432.
Tesch, 1918, p. 77.
Edmondson, 1959, p. 171.

Material : A single ovigerous female 5 mm. broad and 3 mm. long.

Locality : Car Nicobar.

Remarks : A few additional points of interest are noticed in the specimen. The merus of the cheliped has a terminal spinule on the ventral side. A spinule and few granules are seen on the dorsal surface of the carpus. Propodus has a longitudinal ridge on its outer side. Upper surface of propodus has a few beaded ridges running obliquely.

Distribution : The species is known through the Indo-Pacific region to Japan and eastward (Edmondson). This is the first record of the species from Andaman and Nicobar Islands.

Pachygrapsus planifrons de Man

Pachygrapsus planifrons, Borradaile, 1903, p. 432.
Tesch, 1918, p. 77.
Edmondson, 1959, p. 173.

Material : One ovigerous and one non-ovigerous female. The ovigerous female is 4 mm. long and 5 mm. broad.

Locality : Car Nicobar.

Distribution : This is the first record of the species from Andaman and Nicobar Islands.

Sesarma (*Chiromantes*) *bidens* (De Haan)

Sesarma bidens, Heller, 1868, p. 64.
Alcock, 1900, p. 415.

Sesarma (*Chiromantes*) *bidens*, Tesch, 1918, p. 115.
Chopra and Das, 1937, p. 431.

Material : A single male specimen 8.5 mm. long and 10.5 mm. broad.

Locality : Bimbletan, Port Blair.

Remarks : The first male pleopod in this species is stout and straight for most of its length, but near the distal end bends outwards, with a bilobed tip, the larger of the two lobes has a rounded tip. The inner border of the appendage is naked for about 2/3rd the length, beyond which a few bipinnate hairs are seen. Along the outer border, there is a fringe of bipinnate hairs. Beyond the bend part of the appendage, there are simple hairs surrounding the tip.

Distribution : Nicobar (Heller) ; coasts of Bay of Bengal, Andamans, Nicobar (Alcock). The species is known from East Africa to Australia and New Guinea (Chopra and Das).

Metaplax distincta M. Edw.

Metaplax distincta, Alcock, 1900, p. 432.
Tesch, 1918, p. 117.
Chhapghar, 1957, p. 523.

Material : Four males, one female and three juveniles.

Locality : Maya Bandar.

Remarks : The present specimen differs from the previous record as follows. The infraorbital border has bi- or tri-lobed teeth which progressively decrease in length towards the outer side so that their division into inner larger and outer smaller teeth is bound to be arbitrary. The fixed finger has no enlarged teeth. The dactylus exceeds the upper border of the propodus in length.

The first male pleopod is a stout, blunt appendage ; its distal end is enlarged with a blunt projection at the tip pointing slightly outwards. Around this projection are a large number of setae almost concealing the middle projection.

Distribution : Madras, Coconada, Nicobars (Alcock) ; Bombay (Chhapghar). Though Chhapghar mentions that his is the first record of the species from the west coast of India, Tesch in the foot note (p. 117) has already indicated its occurrence in Bombay. Outside India Alcock records it from Mergui also.

Ptychognathus dentatus de Man

Ptychognathus dentata, Alcock, 1900, p. 403.

Ptychognathus dentatus, Tesch, 1918, p. 86.

Material : A single berried female measuring 7 mm. in length and breadth.

Locality : Bimbletan, Port Blair.

Remarks : When compared with Alcock's description of the species the following differences are noticed. The carapace is equal in length and breadth. The inner side of the carpus of *cheliped* lacks the spine and instead there is a tubercle. According to Alcock the presence of a tubercle is distinct character of the male. The dactylus is only twice as long as the upper border of the propodus.

Distribution : The species is recorded for the first time from Andamans. The species is also known from upper Tenasserim (Alcock) and Celebes Sea (de Man).

Plagusia depressa var. *immaculata* Lamarck

Plagusia depressa var. *immaculata*, Laurie, 1906, p. 429.
Tesch, 1918, p. 128.

Plagusia immaculata, Edmondson, 1959, p. 190.

Material : A male 14 mm. broad and 13 mm. long.

Locality : Long Island.

Remarks : As observed by Alcock, this variety lacks the flagellum of exopod of the external maxilliped. But Tesch (1918, p. 128) remarks, ' Alcock states, that in *Plagusia* the exognath of the external maxillipeds is destitute of a flagellum, but already de Haan has figured one in *P. dentipes*, and both Stebbing and Borradaile state the occurrence of a flagellum in *P. capensis*.' The absence of flagellum appears to be more of specific character than generic.

Distribution : The variety is reported for the first time from Andaman and Nicobar Islands. The variety is also known from the Gulf of Mannar (Laurie) ; Hawaiian Islands (Edmondson).

Percnon planissimum (Herbst)

Acanthopus planissimus, Heller, 1868, p. 51.

Liolophus planissimus, Alcock, 1900, p. 439.

Leiolophus planissimum, Borradaile, 1903, p. 432.
Laurie, 1906, p. 429.

Percnon planissimum, Tesch, 1918, p. 130.
Edmondson, 1959, p. 197.
Barnard, 1950, p. 138.

Material : One male, two ovigerous females, smaller ovigerous female measuring 16 mm. in length and 14.5 mm. in breadth.

Locality : South Point. This is a very common species under the stones and dead coral beds.

Distribution : Andamans, Ceylon, Laccadives (Alcock) ; Laccadives (Borradaile) ; The species is also known from Mauritius, Amirante Island, East Coast of Africa, Indo-Pacific (Barnard).

Family OCYPODIDAE

Ocypoda cordimana Desm.

Ocypoda cordimana, Heller, 1868, p. 42.
Henderson, 1893, p. 387.
Alcock, 1900, p. 349.
Tesch, 1918, p. 35.
Gravely, 1927, p. 148.
Pillai, 1951, p. 27.
Chhapghar, 1957, p. 507.

Ocypoda cordimana, Barnard, 1950, p. 84

Material : A female specimen measuring 20.5 mm. in length and 23 mm. in breadth.

Locality : Neill Island.

Distribution : Nicobar (Heller) ; Laccadive, Madras coast, Ceylon, Andamans, Nicobars (Alcock) ; Tuticorin (Henderson) ; Krusadai Island in Gulf of Mannar (Gravely) ; Travancore (Pillai) ; Bombay (Chhapghar). This species is distributed from Tahiti and Japan to Red Sea (Chhapghar).

Ocypoda ceratophthalma (Pallas)

Ocypoda ceratophthalma, Heller, 1868, p. 42.
Henderson, 1893, p. 387.

Alcock, 1900, p. 345.
Laurie, 1906, p. 426.
Tesch, 1918, p. 36.
Gravely, 1927, p. 148.
Chhapghar, 1957, p. 506.

Ocypode ceratophthalma, Borradaile, 1903, p. 96.

Material : A large female 40 mm. long and 45.5 mm. broad, and a small male.

Locality : Neill Island.

Remarks : The granular upper part of the stridulating ridge is seen to vary considerably, often becoming indistinguishable.

Distribution : Nicobar (Heller) ; Tuticorin, Rameswaram (Henderson) ; Krusadai Island in Gulf of Mannar (Gravely) ; Bombay (Chhapghar). The species is also known from Indo-Pacific, from east coast of Africa to Sandwich Islands (Alcock).

Uca annulipes (Latreille)

Gelasimus annulipes, Heller, 1868, p. 38.
Henderson, 1893, p. 388.
Alcock, 1900, p. 353.
Laurie, 1906, p. 425.
Kemp, 1915, p. 221.
Gravely, 1927, p. 148.
Pillai, 1951, p. 28.
Chhapghar, 1957, p. 508.

Ocypode ceratophthalmus, Barnard, 1950, p. 86.

Uca annulipes, Borradaile, 1903, p. 96.

Material : 18 males and four females.

Locality : Aberdeen Bay, Bimnletan and Maya Bandar.

Remarks : The spooned setae agree with the description given by Chhapghar.

Distribution : Nicobar (Heller) ; Tuticorin, Rameswaram (Henderson) ; Chilka Lake (Kemp) ; Kutical backwater in the Gulf of Mannar (Gravely) ; Travancore (Pillai) ; Bombay (Chhapghar) ; The species is also known from Red Sea, coast of Africa to Australia and West Coast of America (Pillai).

Uca marionis excisa Nobili

Gelasimus vocans, Heller, 1868, p. 37.

Gelasimus marionis var. *nitidus*, Alcock, 1900, p. 360.
Gravely, 1927, p. 148.
Chhapghar, 1957, p. 510.

Uca marionis excisa, Tesch, 1918, p. 38.

Material : Two ovigerous females and a male, the smaller ovigerous female 10 mm. long and 14.5 mm. broad.

Locality : Maya Bandar.

Distribution : Nicobar (Heller); Andamans, Coromandel coast, Malabar coast (Alcock); Kutikal Point in the Gulf of Mannar (Gravely); Bombay (Chhapghar).

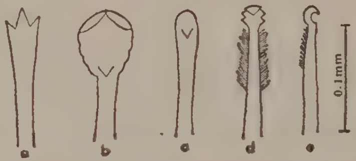

FIG. 3. Spooned setae of (A) *Dotilla wichmanni*; (B, C) *Mictyris longicarpus*; (D, E) *Dotilla myctiroides.*

Dotilla myctiroides (Milne Edwards)

Dotilla myctiroides, Henderson, 1893, p. 390.
Alcock, 1900, p. 368.
Laurie, 1906, p. 426.
Kemp, 1915, p. 227.
Kemp, 1919, p. 326.
Gravely, 1927, p. 149.
Chhapghar, 1957, p. 511.

Dotilla myctiroides, Pillai, 1951, p. 29.

Material : Two male specimens.

Locality : Aberdeen Bay.

Remarks : The lateral parts of the carapace show characteristic sculpturing. Beginning from the posterior upper part is a broad groove which goes forwards up to half the distance from the orbit. Below this is a longitudinal groove almost reaching the orbit. It sends ventralwards two vertical branches. The posterior branch which is long almost reaches the lateral edge of the carapace but the anterior is very short. In front of the posterior branch is a roughly 'Y' shaped groove, the anterior limb of which almost reaches the orbit. Parallel to the lateral border of the carapace is a faint groove which stops behind in front of the insertion of the cheliped. Passing longitudinally almost at the middle of the lateral region is a narrow but deep furrow dividing the surface into two unequal halves.

Cross-section of the dactylus of first three walking legs is rectangular with the corners thickened, and the two narrow lateral sides fringed with hairs. Cross-section of dactylus of the last leg is triangular, with two dorsal and a median ventral carina. In between the two dorsal carinae is a faint carina flanked by two fringes of hairs. The median ventral carina is also provided with a fringe of hairs.

Distribution : Andamans, Coramandel coast (Alcock) ; Chilka Lake, Portuguese India, Tuticorin, Pamban backwaters, Ennur, Port Blair (Kemp) ; Travancore (Pillai) ; Bombay (Chhapghar) ; Kutikal, Pamban, Krusadai Island (Gravely) ; Outside India, the species is known from Singapore, Java, Gaspar straits, Billiton Islands and Mindanao (Kemp).

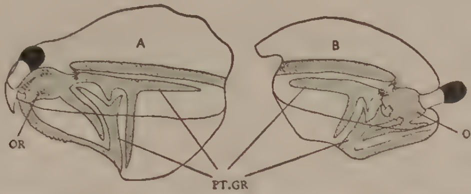

FIG. 4. Pterygostomial grooves in (A) *Dotilla myctiroides* ; (B) *D. wichmanni*. OR—orbit ; PT.GR—pterygostomial grooves.

Dotilla wichmanni de Man

Dotilla wichmanni, Tesch, 1918, p. 45.
Kemp, 1918, p. 277.
Kemp, 1919, p. 329.

Material : Five males and a female.

Locality : Aberdeen Bay.

Remarks : The inner half of the infra-orbital border is serrated, and the outer border uneven as the pterygostomial grooves open into the orbit. The outer half of the infra-orbital border has three lobes, with tuberculated tips, the outermost of which lies just below the outer orbital lobe of the supra-orbital border.

The disposition of the pterygostomial grooves differs slightly from that of *D. myctiroides*. The second vertical groove is not ' Y ' shaped, but has an anteriorly directed branch, which bifurcates, the anterior branch of which opens into the orbit between the first and second infra-orbital lobes. A vertical groove runs down immediately behind the last lobe of infra-orbital border and ends between the second vertical groove and the proximal branch of its anteriorly running groove. Joining the second vertical groove at its base and running close to the border of the pterygostomial region, is an anteriorly running groove, which ends blindly below the orbit. Originating between the second vertical groove and the groove running along the margin of the pterygostomial region, is another groove which takes a sinuous course and opens into the orbit immediately inside the first infra-orbital lobe, and also extends anteriorly.

The tympanum on the inner side of the arm of the cheliped has a fringe of hairs running across it and another fringe running at the upper inner corner of the arm.

The merus of the external maxilliped on its outer surface has three grooves, tow of them running longitudinally and a third one obliquely. Another groove runs along the inner margin of the merus.

The setae on the second maxilliped are in the shape of a three-pronged spear.

The first male pleopod is short, stout appendage curved distally and with a bifid tip. The basal part of the appendage on its outer side has a fringe of branched hairs, whereas the inner border is devoid of hairs. The tip of the appendage has a covering of unbranched hairs.

Distribution : Corbyn's Cove South, Port Blair, Andamans (Kemp). The species is known from Celebes, Makassar, Sumatra, Talaut Island, Gulf of Siam (Kemp).

Macrophthalmus convexus Stimpson

Macrophthalmus convexus, Alcock, 1900, p. 378.
Tesch, 1918, p. 59.
Kemp, 1919, p. 389.

Material : A single male measuring 13 mm. in length and 25.5 mm. in breadth.

Locality : North Bay.

Remarks : The only specimen is found to have a subterminal spine on the upper border of the merus of the first, second and third walking legs. Alcock has noticed subterminal spines on 2nd and 3rd walking legs only.

The first male pleopod is a stout appendage with an enlarged distal end and has a small projection at the distal end. The arrangement of the hairs is as shown in the diagram.

Distribution : Andamans (Alcock), Pamban (Kemp). The species is also known from the Gulf of Mannar to Australia, Loo Choo Islands and Hawaii (Kemp).

Macrophthalmus telescopicus (Owen)

Macrophthalmus verrauxi, Alcock, 1900, p. 377.

Macrophthalmus telescopicus, Tesch, 1918, p. 58.
Kemp, 1919, p. 387.
Gravely, 1927, p. 150.

Material : A female 10 mm. long and 16 mm. broad.

Locality : Andamans.

Distribution : Andamans (Alcock) ; Backwater at Pamban, Gulf of Mannar (Kemp) ; Krusadai Island in Gulf of Mannar (Gravely). The species is very widely distributed in Indo-Pacific region from Red Sea to Hawaii, Japan and Australia.

Family MICTYRIDAE

Mictyris longicarpus Latreille

Mictyris longicarpus, Alcock, 1900, p. 384.
Tesch, 1918, p. 42.

Material : Two males and a female.

Locality : Maya Bandar.

Remarks : The ischium of the enlarged cheliped of the male has a spine on its inner side but is absent in the female. A longitudinal carina is also clear on the inner side of the palm (Tesch). The dactylus of the last leg is curved upwards.

Though the male as well as the female have equally broad abdomen they can be distinguished by the shape of the various segments. The end segments of the abdomen of the female is semi-circular whereas in the male it is very broad and short. In the female, the segments are demarcated by deep lateral incisions which are comparatively indistinct in the male.

The spooned setae on the second maxilliped may be either well spooned or only partly so. In the well-spooned setae, the tip is bilobed with either borders of the spoon serrated.

The first male pleopod is a short appendage with a pointed tip, pointing outwards.

Distribution : Andamans, Nicobars (Alcock) ; Outside India the species is known from Philippine Sea, Banda Sea and Java Sea.

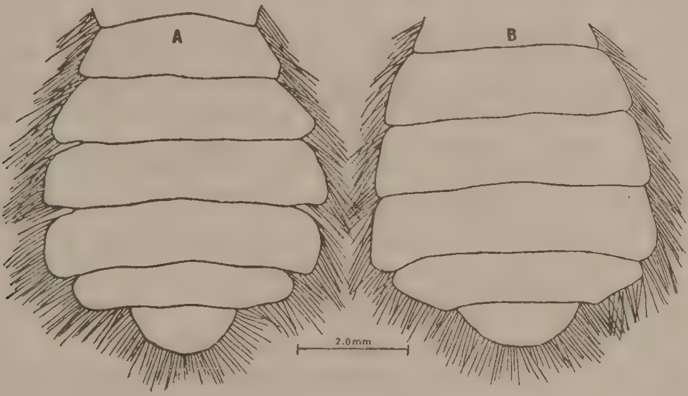

Fig. 5. Abdomen of *Mictyris longicarpus*. (A) female ; (B) male.

SUMMARY

The present paper forms the first instalment in a series of papers on the Brachyura of the Andaman and Nicobar Islands and deals with the families Portunidae, Ocypodidae, Grapsidae and Mictyridae. Twenty-nine species and a variety are described of which eight species and a variety are new records for this locality.

ACKNOWLEDGEMENTS

I take this opportunity to express my grateful thanks to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for all facilities given in this study and for the valuable criticism and guidance. I am also grateful to Dr. N. Krishna Pillai, Marine Biological Laboratory, Trivandrum for going through the manuscript and offering suggestions.

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ON SOME CRABS (DECAPODA-BRACHYURA) FROM THE LACCADIVE ARCHIPELAGO[1]

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Earlier investigations on the brachyuran fauna of the Maldive and Laccadive Archipelagos were initiated by Alcock (1895, 1896, 1898, 1899, 1899b and 1900) ; who recorded 43 species of crabs belonging to 9 families. Subsequently, Borradaile (1903 and 1906) reported 191 species including 27 already described by Alcock ; which brought up the total record from this region to 207 species. The present account deals with 36 species of which 5 have hitherto not been described from these regions. Of the above 5 species (indicated by a single asterisk in the list given below) 4 are not known from the Indian peninsula. Another 11 species (denoted by double asterisks) have been previously reported from the Maldives but not from the Laccadives. Out of the 36 species reported in this paper, 29 species have been collected from Minicoy and the rest from Kavarathy, Amenidivi and Bitra Islands.

Part of the material was kindly handed over to me by Dr. S. Jones, who collected them in 1958 during a cruise to the Laccadive Islands. Additional material was collected in the year 1961 by Messrs. P. T. Thomas, and Alimanickfan from Minicoy and by Mr. P. M. Sayeed from the Laccadive and Amenidive Islands.

The following is the list of species reported in this paper :—

Family : PORTUNIDAE

1. ***Thalamita tenuipes* Borradaile.
2. **T. integra* Dana.
3. *T. admete* (Herbst).
4. *T. cooperi* Borradaile.
5. **Charybdis* (*Goniosupradens*) *obtusifrons* Leene.
6. ***Portunus granulatus* (Milne-Edwards).

Family : GRAPSIDAE

7. *Grapsus tenuicrustatus* (Herbst).
8. *Geograpsus crinipes* (Dana).
9. *Percnon planissimum* (Herbst).

Family : OCYPODIDAE

10. *Ocypoda ceratophthalma* (Pallas).
11. *O. cordimana* Desmarest.

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Family : XANTHIDAE

12. *Carpilius maculatus* (Linnaeus).
13. *C. convexus* (Forskal).
14. **Carpilodes tristis* Dana.
15. **C. bellus* (Dana).
16. ***Platypodia anaglypta* (Heller).
17. *Zozymus aeneus* (Linnaeus).
18. *Daira perlata* (Herbst).
19. *Actaea cavipes* (Dana).
20. *Leptodius sanguineus* (Milne-Edwards).
21. *Chlorodopsis spinipes* (Heller).
22. ***Cymo quadrilobatus* Miers.
23. ***Pilumnus vespertilio* Fabricius.
24. *Trepezia maculata* (Macleay).
25. *T. ferruginea* (Latreille).
26. *T. cymodoce* (Herbst).
27. *Tetralia glaberrima* (Herbst).
28. *Lybia tessellata* (Latreille).

Family : MAIIDAE

29. *Menaethius monoceros* (Latreille).
30. ***Huenia proteus* de Haan.
31. ***Tylocarcinus styx* (Herbst).
32. ***Schizophrys aspera* (Milne-Edwards).
33. ***Micippa philyra* (Herbst).

Family : PARTHENOPIDAE

34. **Parthenope horrida* Fabricius.

Family : CALAPPIDAE

35. ***Matuta banksii* Leach.
36. *Calappa hepatica* (Linnaeus).

Family : PORTUNIDAE

Thalamita tenuipes Borradaile

Thalamita tenuipes, Borradaile, 1903, p. 204.

Material : 3 males and 2 females ; the largest of the males 20 mm. long and 30 mm. broad.

Locality : Minicoy.

Remarks : The species can easily be distinguished from *T. prymna* by the presence of the spiny inner end of the infra-orbital border, the acute tip of which in one case is worn out but retains a small blunt projection. The dactylus of the walking legs has broad reddish bands alternating with narrow white bands.

The species is distinguished from *T. prymna* by the nature of the first male pleopod (Fig. I, A) due to the presence of bristles on the inner border also.

Distribution : Goidu and Goifurfehendu in Maldive Archipelago (Borradaile). The present report extends its distribution into the Laccadive Archipelago also.

Thalamita integra Dana

Thalamita integra, Alcock, 1899, p. 85.
Stephenson and Hudson, 1957, p. 339.

Material : An ovigerous female 16 mm. long and 25 mm. broad.

Locality : Minicoy.

Distribution : The species has so far not been reported from these islands. The species is known from East Africa and Red sea to Fiji.

Thalamita admete (Herbst)

Thalamita admeta, Alcock, 1899, p. 82.
T. admeta var. *A. admeta*, Borradaile, 1903, p. 202.
T. admeta var. *B. edwardsi*, Borradaile, 1903, p. 202.
T. admeta var. *C. savignyi*, Borradaile, 1903, p. 202.
T. admeta, Stephenson and Hudson, 1957, p. 320.

Material : 1 immature male 17 mm. long and 29 mm. broad.

Locality : Minicoy.

Distribution : Goidu, Fadifolu, S. Mahlos, North Male, Mahlos and Minicoy (Borradaile). The species is also known from East Africa, Red Sea to Japan, Hawaii and Fiji (Stephenson and Hudson).

Thalamita cooperi Borradaile

Thalamita cooperi, Borradaile, 1903, p. 206.
Stephenson and Hudson, 1957, p. 331.

Material : A male 6 mm. long and 9 mm. broad.

Locality : Minicoy.

Remarks : The first male pleopod (Fig. I, B) in this species is characteristic and differs distinctly from all the known species. It is a stout appendage which near the tip bends outwards and ends bluntly, with thick short bristles along the border. Subterminally on the ventral side of the appendage is a patch of simple bristles.

Distribution : Goidu, Hulule, and Minicoy (Borradaile); Queensland (Stephenson and Hudson).

Charybdis (Goniosupradens) obtusifrons Leene

Charybdis (*Goniosupradens*) *obtusifrons*, Leene, 1938, p. 140.

Material : One female 30 mm. long and 47 mm. broad.

Locality : Minicoy.

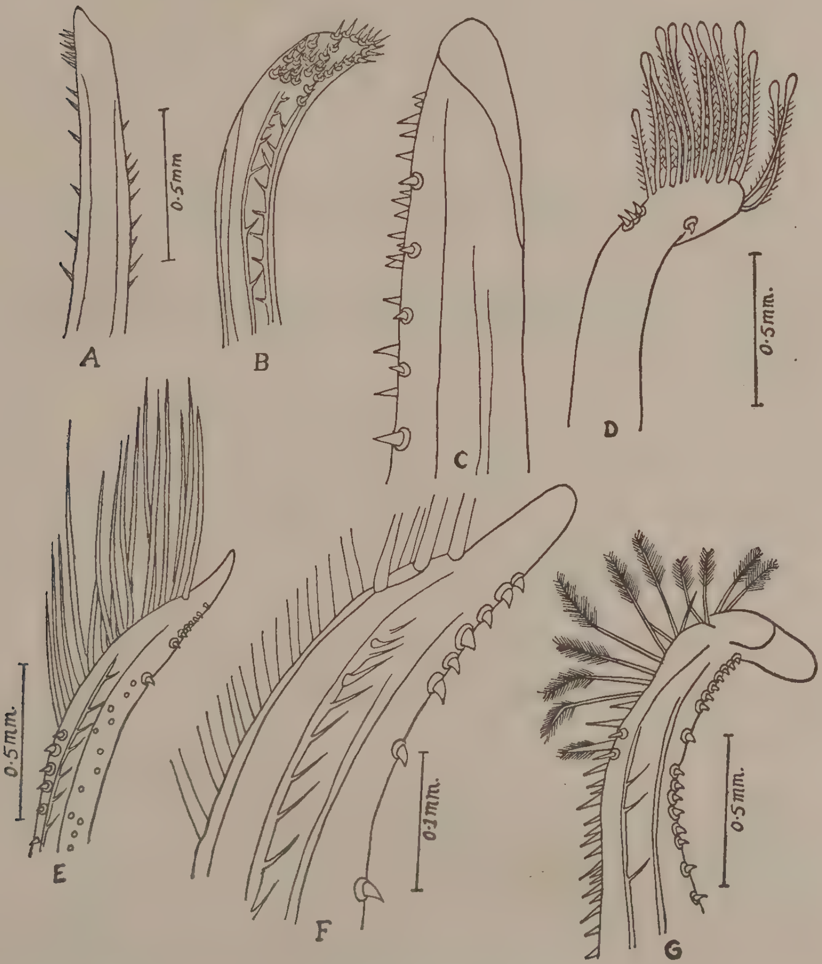

FIG. 1. Male pleopods of (A) *Thalamita tenuipes*. (B) *T. cooperi*. (C) *Carpilius convexus*. (D) *Carpiloides tristis*. (E) *Platypodia anaglypta*. (F) *Actaea cavipes*. (G) *Cymo quadrilobatus*.

Remarks : The specimen agrees in all details with the description given by Leene, except for the left natatory leg, all other appendages are missing.

Distribution : The species has previously been recorded from Red Sea, Japan and Djeddah. This is the first record of this species from the Indian waters.

Portunus granulatus (Milne-Edwards)

Neptunus (*Achelous*) *granulatus*, Alcock, 1899, p. 45.
Borradaile, 1903, p. 208.
Portunus granulatus, Stephenson and Campbell, 1959, p. 108.

Material : A male 18 mm. long and 25.5 mm. broad.

Locality : Minicoy.

Remarks : The median frontal lobes are distinctly separate, 2nd, 4th and 6th antero-lateral teeth are subequal and smaller than 3rd, 5th and 7th which are also subequal.

Distribution : Haddumati, Suvadiva, Felidu, South Nilandu, Male, Kolumadulu, Miladumadulu and Mahlos in Maldives (Borradaile). The present report extends its distribution to the Laccadives also. The species is known from Red Sea to Hawaii.

Family : GRAPSIDAE

Grapsus tenuicrustatus (Herbst)

Grapsus grapsus, Alcock, 1900, p. 392.
Grapsus maculatus gracilipes, Tesch, 1918, p. 72.
Grapsus tenuicrustatus, Banerjee, 1960, p. 134.

Material : A large female 62 mm. long and 66 mm. broad.

Locality : Minicoy.

Remarks : Banerjee (1960) mentions that all Indo-Pacific forms should be called by the name *G. tenuicrustatus*. He enumerates the differences between *G. tenuicrustatus* and *G. grapsus* ; the latter according to him is restricted in distribution to Atlantic and West American region. Of the five distinguishing characters, he considers the ridge on the epistome as very characteristic and constant in the two species. (1) But the single large specimen in the present collection has a very faint ridge on the epistome, which is continuous and at the inner end converges posteriorly towards the median line. (2) The front in this specimen is half as wide as deep. (3) There is only one short ridge on the carapace between the last transverse ridge and the ridge anterior to it. (4) The postero-lateral part of the carapace has a wrinkled appearance due to the presence of broad longitudinal ridges. The foregoing description indicates that the specimen agrees with *G. grapsus* in characters (1) and (2), whereas in the characters (3) and (4) it agrees with *G. tenuicrustatus*.

Since only a single specimen is available it has provisionally been referred to the latter species.

Distribution : Laccadives (Alcock). Has a wide distribution in the Indo-Pacific region from Red Sea and east coast of Africa to Japan, Australia, Polynesian Islands and Hawaii (Banerjee).

Geograpsus crinipes (Dana)

Geograpsus crinipes, Alcock, 1900, p. 396.
Borradaile, 1903, p. 67.
Banerjee, 1960, p. 163.

Material : One male 48 mm. long and 57 mm. broad.

Locality : Minicoy.

Distribution : Laccadives (Alcock) ; Minicoy (Borradaile) : The species is also known from Red Sea to Japan, Samoa and Hawaii.

Percnon planissimum (Herbst)

Liolophus planissimum, Alcock, 1900, p. 439.
Leiolophus planissimum, Borradaile, 1903, p. 432.
Percnon planissimum, Tesch, 1918, p. 130.
Barnard, 1950, p. 138.

Material : One immature male 8.5 mm. long and 6 mm. broad.

Locality : Minicoy.

Distribution : Laccadives (Alcock). Borradaile mentions that it has a very wide distribution in these islands. The species is also known from Mauritius, Amirante Islands, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Family : OCYPODIDAE

Ocypoda ceratophthalma (Pallas)

Ocypoda ceratophthalma, Alcock, 1900, p. 345.
Tesch, 1918, p. 36.
Borradaile, 1903, p. 67, 96.
Ocypode ceratophthalmus, Barnard, 1950, p. 86.

Material : 21 males, 12 females and 13 juveniles.

Locality : Kavarathy and Amenidive Islands.

Distribution : Maldive Islands and Minicoy (Borradaile). The species is also known from Mauritius, east coast of Africa, South Africa, Red Sea, Indo-Pacific (Barnard).

Ocypoda cordimana Desmarest

Ocypoda cordimana, Alcock, 1900, p. 349.
Borradaile, 1903, p. 67, 96.
Ocypode cordimanus, Barnard, 1950, p. 84.

Material : 3 males and a female which is the largest, 21 mm. long and 24 mm. broad.

Locality : Kavarathy Island.

Distribution : Laccadives (Alcock) ; Minicoy and Maldives (Borradaile). The species is also known from Mauritius, east coast of Africa, South Africa, and Red Sea to Japan (Barnard).

Family : XANTHIDAE

Carpilius convexus (Forskal)

Carpilius convexus, Alcock, 1898, p. 80.
Borradaile, 1903, p. 261.
Barnard, 1950, p. 205.

Material : One male 28 mm. long and 39 mm. broad.

Locality : Minicoy.

Remarks : The first male pleopod (Fig. I,C) is a stout almost straight appendage which has a rounded tip. Along the inner border are a number of spinules of varying size.

Distribution : Fadifolu, Male, North Male, and Minicoy (Borradaile). The species is also known from Mauritius, Red Sea, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Carpilius maculatus (Linnaeus)

Carpilius maculatus, Alcock, 1898, p. 79.
Borradaile, 1903, p. 261.
Barnard, 1950, p. 203.

Material : A large male 85 mm. long.

Locality : Minicoy.

Remarks : Two pairs of additional blotches, a pair in front and a pair behind the transverse row of three blotches in the middle of the carapace are noticed.

Distribution : Minicoy, Maldives (Borradaile).

Carpilodes tristis Dana

Carpilodes tristis, Alcock, 1898, p. 82.

Liomera tristis, Barnard, 1950, p. 237.

Material : An ovigerous female 13.5 mm. long and 23 mm. broad and a male.

Locality : Minicoy.

Remarks : The ground colouration of the carapace varies in the two sexes, in the female it is brownish in colour, whereas in the male it is whitish. A distinct reddish band is clearly visible on the antero-lateral border of the carapace immediately behind the orbit. The legs have alternate bands of white and red colour.

The first male pleopod (Fig. I, D) is distinctly curved near the tip towards the outer side, with a rounded tip. Near the tip and also at the tip, there are more than a dozen long bipinnate hairs, which have enlarged tips. Preceding these bipinnate hairs, on the inner side are a few large spines, their size increasing distally.

Distribution : Andamans and Nicobar (Alcock). This is the first record of the species from Laccadive Islands.

Carpilodes bellus (Dana)

Liomera bellus, Barnard, 1950, p. 238.

Material : Two males and an ovigerous female which is 4 mm. long and 6 mm. broad.

Locality : Minicoy.

Distribution: This is the first record of the species from the Laccadive Islands. The species has been known from Mauritius, South Africa, Indo-Pacific (Barnard).

Platypodia anaglypta (Heller)

Lophactaea anaglypta, Alcock, 1898, p. 102.
Borradaile, 1903, p. 258.

Platypodia anaglypta, Barnard 1950, p. 208.

Material : A male 10.5 mm. long and 16 mm. broad.

Locality : Minicoy.

Remarks : The dark colouration of the fixed finger extends to a major part of the palm—towards the proximal end as well as upwards.

The first male pleopod (Fig. I, E) towards the tip smoothly curves outwards and has a pointed tip. Subterminally along the inner border is a tuft of very long, simple hairs preceded by a few spinules; along the outer border are a few smaller spinules irregularly arranged.

Distribution : Hulule, Male (Borradaile). The present report extends its distribution into the Laccadive islands also.

Zozymus aeneus (Linnaeus)

Zozymus aeneus, Alcock, 1898, p. 104.
Borradaile, 1903, p. 258.
Barnard, 1950, p. 210.

Material : One female 40 mm. long and 62 mm. broad.

Locality : Bitra Island.

Remarks : An abnormality is noticed in the specimen in having only three teeth along the antero-lateral border of the carapace on the right side ; whereas there are four normal teeth on the left side ; in consequence the last two teeth on the right side are broader than those on the left.

Distribution : Laccadives (Alcock). Male and Minicoy (Borradaile). The species is also known from Mauritius, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Daira perlata (Herbst)

Daira perlata, Alcock, 1898, p. 155.
Borradaile, 1903, p. 258.

Material : A female 38 mm. long and 54 mm. broad.

Locality : Minicoy.

Distribution : Laccadive reefs (Alcock) ; Minikoi and Goifurfehendu Atolls (Borradaile).

Actaea cavipes (Dana)

Actaea cavipes, Alcock, 1898, p. 147.
Borradaile, 1903, p. 258.
Barnard, 1950, p. 229.

Material : A male 4.5 mm. long and 7 mm. broad.

Locality : Minicoy.

Remarks : The fronto-oribtal border is decidedly more than half the greatest breadth of the carapace. The first antero-lateral lobe of the carapace is hardly recognisable due to its confluence with the outer orbital lobe. Fingers are pointed.

The first male pleopod (Fig. I, F) curves near the distal end towards the outer side, a part of the distal end being uniformly thick and finger like. Along the inner border and subterminal in position is a tuft of long simple hairs. Along the outer border and on the ventral side near the distal end are a few spinules.

Distribution : Minicoy (Borradaile). The species is also known from Mauritius, Red Sea, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Leptodius sanguineus (Milne-Edwards)

Xantho (Leptodius) sanguineus, Alcock 1898, p. 119.
Leptodius sanguineus, Borradaile, 1903, p. 252.

Material : Two males, the larger of the two 22.5 mm. long and 37 mm. broad.

Locality : Minicoy.

Distribution : Laccadives (Alcock), Goifurfehendu (Borradaile).

Chlorodopsis spinipes (Heller)

Chlorodopsis spinipes, Alcock, 1898, p. 169.
Borradaile, 1903, p. 261.

Material : One juvenile 9 mm. long and 13 mm. broad.

Locality : Minicoy.

Remarks : The outer angle of front is not spiny. The merus of cheliped has about 4 to 6 spines on its posterior border.

Distribution : Male and Minicoy (Borradaile).

Cymo quadrilobatus Miers

Cymo quadrilobatus, Alcock, 1898, p. 175.
Borradaile, 1903, p. 257.

Material : One male and an ovigerous female 18 mm. long and 20 mm. broad.

Locality : Minicoy.

Remarks : The first male pleopod (Fig. I, G) is a large appendage curved outwards with a spatulate, flat and rounded tip which is slightly twisted. Along the outer border, near the tip are a few long bipinnate hairs preceded by large spinules. Along the inner border are a large number of small spinules.

Distribution : Male, Goifurfehendu, Fadifolu (Borradaile). The present report extends its distribution to the Laccadives also.

Pilumnus vespertilio Fabricius

Pilumnus vespertilio, Alcock, 1898, p. 192.
Borradaile, 1903, p. 245.
Barnard, 1950, p. 263.

Material : A juvenile 6 mm. long and 8 mm. broad.

Locality : Minicoy.

Distribution : Hulule, Male, Funadu, Velu and Miladumadulu (Borradaile). The present report extends its distribution to the Laccadives also. The species is known from Mauritius, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Trapezia maculata (Macleay)

Trapezia maculata, Alcock, 1898, p. 221.
Trapezia ferruginea var. *maculata*, Borradaile, 1903, p. 265.

Material : 4 ovigerous females, 4 males, the largest ovigerous female 20 mm. long and 23.5 broad.

Locality : Minicoy.

Distribution : Goifurfehendu, Male, Fadifolu, Suvadiva, South Nilandu, and Minicoy (Borradaile).

Trapezia ferruginea Latreille

Trapezia ferruginea, Alcock, 1898, p. 220.
Borradaile, 1903, p. 264.

Material : 2 ovigerous females and 2 males. The smaller ovigerous female 8 mm. long and 10.5 mm. broad.

Locality : Minicoy.

Distribution : Goifurfehendu, Male, Fadifolu, Addu, South Nilandu, Suvadiva, South Male and Minicoy (Borradaile).

Trapezia cymodoce (Herbst)

Trapezia cymodoce, Alcock, 1898, p. 219.
Borradaile, 1903, p. 265.
Barnard, 1950, p. 276.

Material : 5 males and 4 ovigerous females. The smallest ovigerous female 7 mm. long and 9 mm. broad.

Locality : Minicoy.

Distribution : Male, Goifurfehendu, Fadifolu, South Nilandu, Suvadiva, Felidu and Minicoy (Borradaile). The species is also known from Ibo, Portuguese East Africa, South Africa, Zanzibar, Red Sea, Indo-Pacific (Barnard).

Tetralia glaberrimma (Herbst)

Tetralia glaberrimma, Alcock, 1898, p. 223.
Borradaile, 1903, p. 265.
Barnard, 1950, p. 280.

Material : 2 ovigerous females, the smaller of which 6 mm. long and 7 mm. broad ; and 2 males.

Locality : Minicoy.

Distribution : Maldives (Alcock) ; Goifurfehendu, Fadifolu, Male, Felidu and Minicoy (Borradaile). The species is also known from Ibo, Portuguese East Africa, South Africa, Red Sea, Seychelles, Indo-Pacific (Barnard).

Lybia tessellata (Latreille)

Melia tussellata, Borradaile, 1903, p. 250.
Lybia tessellata, Barnard, 1950, p. 249.

Material : 2 males, 4 non-ovigerous females and an ovigerous female, 7 mm. long and 8 mm. broad.

Locality : Minicoy.

Remarks : The ovigerous female carried an anemone in each cheliped whereas the non-ovigerous female is without any anemone.

The first male pleopod (Fig. II, A, B) is curved near the tip with the sharp pointed tip pointing outwards. Along the inner border are a number of short bipinnate hairs, preceded by a few spinules. Subterminally, on the ventral side another row of short bipinnate hairs are seen, the distal hairs of which are simple and short. Along the outer border are a number of small spinules of varying size

Distribution : Male, Addu, Goifurfehendu, and Minicoy (Borradaile). The species is also known from Mauritius, South Africa, Seychelles and Hawaiian Island (Barnard).

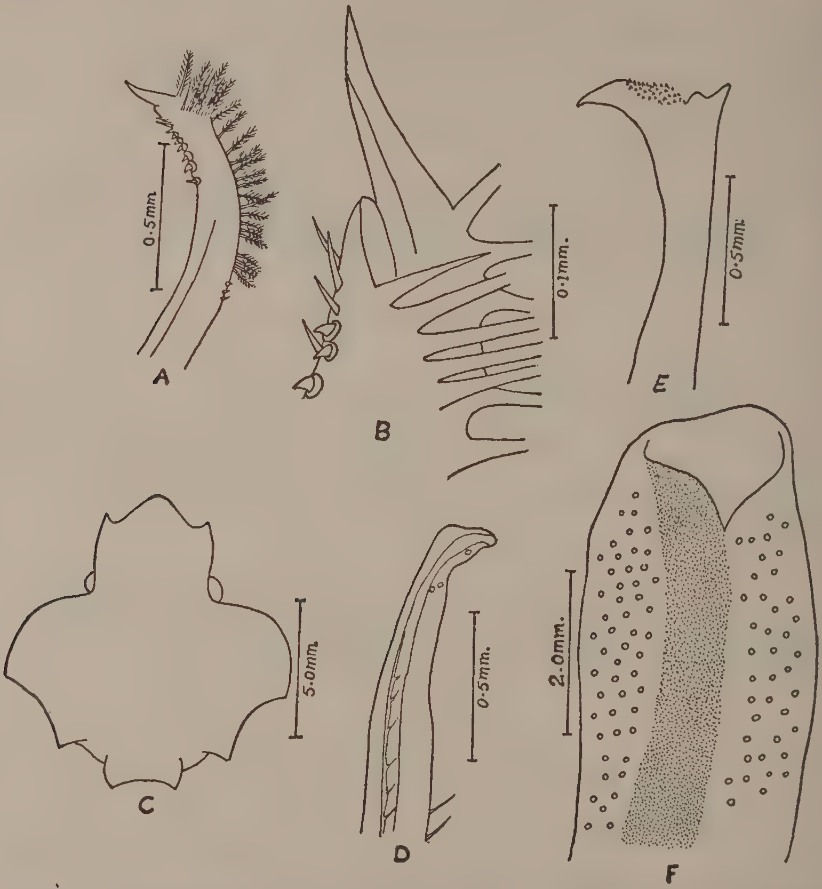

FIG. 2. Male pleopods of: (A & B) *Lybia tessellata.* (D) *Huenia proteus.* (E) *Tylocarcinus styx.* (F) *Parthenope horrida.* (C) Carapace of *Huenia proteus.*

Family : MAIIDAE

Huenia proteus de Haan

Huenia proteus, Alcock, 1895, p. 195.
Borradaile, 1906, p. 686.
Laurie, 1906, p. 372.
Barnard, 1950, p. 41.

Material : A male 10.5 mm. long and 10 mm. broad.

Locality : Minicoy.

Remarks : The carapace in this specimen (Fig. II, C) is almost like the figure (XLVII, 1a) given by Borradaile.

The first male pleopod (Fig. II, D) resembles to a great extent that of *Menaethius monoceros* but has a less enlarged tip.

Distribution : Male, and Kolumadulu. The present report extends its distribution into the Laccadive Islands also. The species is also known from east coast of Africa, South Africa, Indo-Pacific to Australia, China, Japan and Fiji Islands (Barnard).

Menaethius monoceros (Latreille)

Menaethius monoceros, Alcock, 1895, p. 197.
Borradaile, 1906, p. 686.
Barnard, 1950, p. 43 .

Material : A male and an ovigerous female 13 mm. long (inclusive of rostrum) and 10 mm. broad.

Locality : Minicoy.

Distribution : Male, Fadifolu, Goifurfehendu, and Minicoy (Borradaile). The species is also known from Red Sea, east coast of Africa, South Africa, Mauritius, Indo-Pacific to Australia, China, Fiji, Sandwich Islands (Barnard).

Tylocarcinus styx (Herbst)

Tylocarcinus styx, Alcock, 1895, p. 235.
Borradaile, 1906, p. 688.

Material : 4 males.

Locality : Minicoy.

Remarks : The first male pleopod (Fig. II, E) is a straight appendage, which has a transparent triangular expansion on its outer side at the tip.

Distribution : Male, Fadifolu, Goifurfehendu, (Borradaile). The present report extends its distribution into the Laccadive Islands also.

Schizophrys aspera (Milne-Edwards)

Schizophrys aspera, Alcock, 1895, p. 243.
Borradaile, 1906, p. 688.
Barnard, 1950, p. 60.

Material : A male 20 mm. long (with rostrum) and 20 mm. broad (inclusive of lateral spines).

Locality : Kavarathy Island.

Distribution : Male, Fadifolu, Felidu, Suvadiva (Borradaile). The present report extends its distribution into the Laccadive Islands also. The species is also known from Indo-Pacific to Japan, Australia and Samoa (Barnard).

Micippa philyra (Herbst)

Micippa philyra, Alcock, 1895, p. 249.
Borradaile, 1906, p. 689.

Material : A male 20 mm. long and 16 mm. broad.

Locality : Minicoy.

Remarks : The first male pleopod is short and curved, the tip pointing outwards ; near the tip on the ventral side of the appendage are a few short spinules.

Distribution : Hulule, Male, Kolumadulu, South Nilandu, Fadifolu, Suvadiva and North Male (Borradaile). The present report extends its distribution into the Laccadive Islands also.

Family : PARTHENOPIDAE

Parthenope horrida Fabricius

Parthenope horrida, Alcock, 1895, p. 279.
Barnard, 1950, p. 64.

Material : 1 male 45 mm. long and 62 mm. broad.

Locality : Minicoy.

Remarks : The first male pleopod (Fig. II, F) is a stout and straight appendage ending bluntly where the wide opening of the seminal canal is located. The ventral surface of the appendage towards the tip has microscopic spinules.

Distribution : Off Ceylon (Alcock). This is the first record of the species from the Laccadive Islands. The species is also known from Natal, Mauritius, Indo-Pacific (Barnard).

Family : CALAPPIDAE

Matuta banksii Leach

Matuta banksii, Alcock, 1896, p. 158.
Borradaile, 1903, p. 436.
Barnard, 1950, p. 359.

Material : 2 males and 2 females of which 1 is ovigerous 28 mm. long and 41 mm. broad (with spines).

Locality : Kavarathy Island.

Distribution : Hulule, Male (Borradaile). The present report extends its distribution into the Laccadive Islands also. The species is also known from Mauritius, Red Sea, east coast of Africa, South Africa, Indo-Pacific (Barnard).

Calappa hepatica (Linnaeus)

Calappa hepatica, Alcock, 1896, p. 142.
Borradaile, 1903, p. 436.
Barnard, 1950, p. 348.

Material : A female 60 mm. broad and 40 mm. long.

Locality : Minicoy.

Distribution : Hulule, Male Atoll, Minicoy (Borradaile). The species is also known from South Africa, east coast of Africa, Red Sea, Mauritius, Madagascar, Indo-Pacific, Australia (Barnard).

SUMMARY

Included in the present paper, are 36 species of crabs collected from the Laccadive Archipelago. Of the 36 species in the collection, 5 species are new records for this region.

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STUDIES ON THE SHRIMP *CARIDINA LAEVIS* (HELLER)

III. The Respiratory System

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This paper, the third of the series on *Caridina laevis*, deals with the respiratory system ; the accounts on the digestive system and the reproductive system have been published (Pillai, 1960*a* and 1960*b*).

The structure and histology of the gills of Crustacea have been studied only in a few forms. The dissimilarity in structure described by different workers in the various forms is very great (Allen 1893, Pearson 1908, Patwardhan 1937, Webb 1940, Smyth 1942 and Pike 1947). It may be remarked that this disparity is at least partly contributed by the difficulty in getting the material fixed properly.

Methods

Many workers have commented on the difficulty of obtaining good fixation of the branchiae. In the present study, the branchiae were removed from the body before fixing. The pleural membrane with the pleurobranchs was removed quickly and dropped in warm fixing fluids. The entire animal was also sectioned with a view to studying the branchial circulation. Fixatives employed were strong Fleming, Champy's, Helly's and Gilson's fluids. Sections were stained in iron haematoxylin, Heidenhain's Azan and Delafield's haematoxylin. Some fixed in formalin-Zenker were stained in methyl-green-pyronin (Cowdry, 1959). Although the cytological details were poor in the latter, the distribution of blood sinus inside the gill lamella was very clear. The blood sinus appears empty and non-stained in contrast to the brilliant colour of pyronin. The branchial circulation was studied in live animals by fastening them to glass slides on their sides by the help of thin rubber bands and the gills *in situ* were examined under the low power of the stereoscopic binocular microscope in strong transmitted light. Because of the transparency, the course of circulation is clear and this study is facilitated by the refractivity of the corpuscles which show clearly the direction of the flow of blood.

The Branchial Cavity

The line of attachment of the branchiostegite to the carapace dips above the second maxilliped (fig. 1). Consequently the branchial cavity also tapers in front and is demarcated in front by the epimeron of the mandibular segment. This cavity which encloses the branchiae is open below, behind and in front. The lower rim of the branchiostegal membrane is in contact with the coxae of the walking legs. The epipodites are all placed in one line in an antero-posterior direction on

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the respective coxal segments. They bridge the adjacent coxae and water enters the branchial cavity through a series of slits between the coxae. The feathery bristles of the long exopodite of the first pleopod, which is apposed along these slits extend anteriorly upto the base of the third maxilliped in the male and upto the coxa of the first walking leg in the female. These act as sieves preventing the ingress of debris into the branchial cavity with the respiratory current. Behind, the branchial cavity is in communication with the ventral space enclosed by the pleura of the abdominal segments. In front of the branchial cavity and enclosed by the anterior part of the branchiostegite is a space which may be named as the prebranchial cavity, situated on the outer side of the mandible. This diverges anteriorly leading to the outside.

The Respiratory Current

The maintenance of the respiratory current of water is brought about by the working of the flattened scaphognathite of the second maxilla. Its point of attachment to the body is almost directly above the first gill and tapers behind ending in a truncated apex above the branchia of the segment bearing the first walking leg. This end bears a tuft of long and stiff bristles. The flattened end extends into the prebranchial cavity. The branchial cavity leads to the prebranchial cavity which is triangular in cross section (fig. 2). Towards its inner side are the gnathobases of the various mouthparts and laterally is the branchiostegite. The wide gape below is closed by the flattened exopod of the first maxilliped. It has no movement of its own as is generally supposed to assist the scaphognathite but closes the lower opening of the prebranchial cavity so that water is sucked from the branchial cavity from behind and not from below.

Analysis of the movements of the scaphognathite shows that the maximum amplitude is attained by the anterior fringed region because its pivot is behind the middle. The anterior part is flattened and pliable. The posterior part is rigid and flattened vertically and the movement is in a see-saw fashion around the pivot. The posterior part moves over the gills without disturbing the water inside the branchial cavity. But when the anterior part in its turn moves up or down, it bales out a quantity of water from the prebranchial cavity forwards. Consequently, with every beat of this region, more water is drawn from the branchial cavity. The water is expelled in jerks, in unison with the upward or downward movement of the scaphognathite.

The course of the current of water was studied by putting crystals of stain around the branchial cavity of live specimens observed under the binocular microscope. The inhalent current of water enters the branchial cavity from below and behind. The lower ends of the gills are blunt and these are placed in such a way that a current of water entering the branchial cavity in between the coxae, strikes the gill at its lower apex, divides into two and flows on either side. These currents pass upwards and forwards between the slanting gills and collect as one at the upper anterior part of the branchial cavity from where leads the prebranchial cavity with its efficient device for baling out water. Water from behind viz. from the space below the abdomen also enters the branchial cavity. By the vigorous movements of the exopods of the second and third maxillipeds, the exhalent water is driven away towards the anterior side.

The gills are typical phyllobranchs with two rows of flattened gill lamellae attached to an elongated axis. The attachment of each gill to the body is below

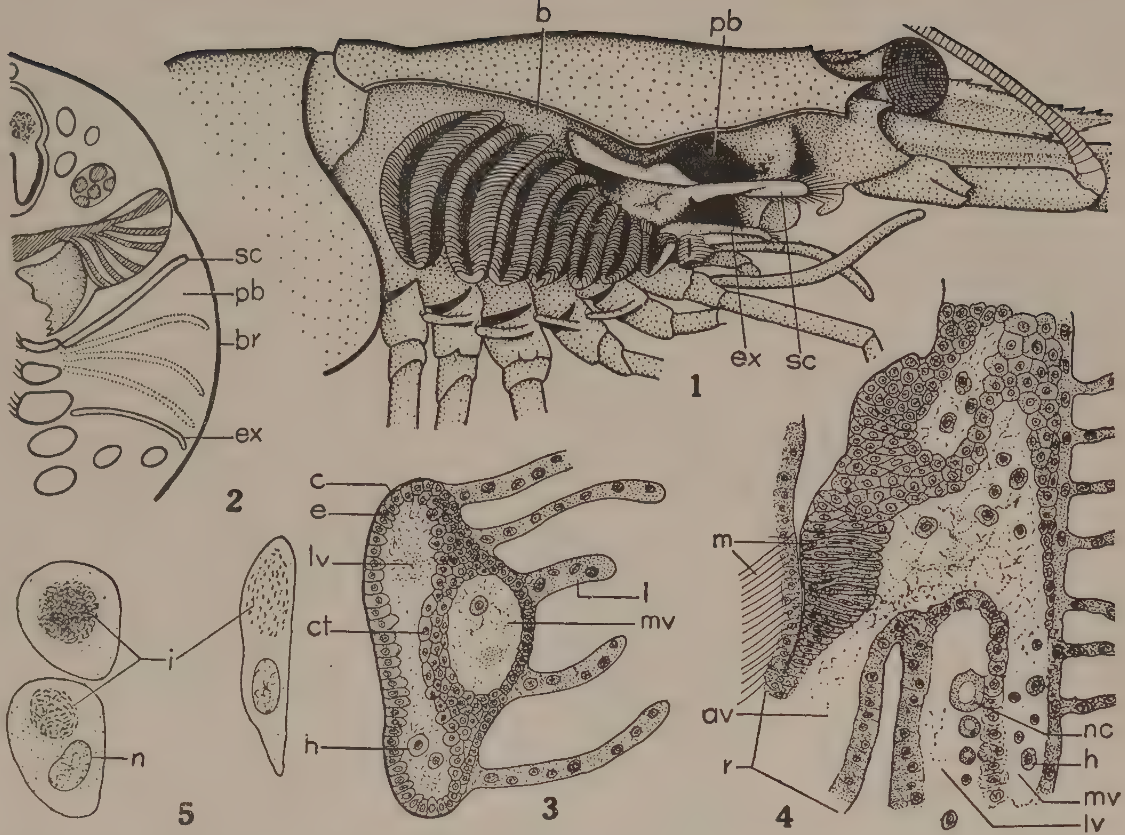


FIG. 1. Lateral view of branchiae after cutting the branchiostegite through its line of attachment. b. branchial cavity, ex. exopodite of first maxilliped, pb. prebranchial cavity, sc. scaphognathite.

FIG. 2. Diagrammatic cross section through prebranchial cavity. br. branchiostegite. Other letterings as in figure 1.

FIG. 3. Cross section through the branchial axis. c. cuticle, ct. connective tissue, e. epithelium, h. haemocyte, l. gil almella, lv. lateral branchial vein, mv. median branchial vein.

FIG. 4. Longitudinal section through the branchial axis. av. afferent branchial vein, m. muscle fibre, nc. nephrocyte, r. branchial root.

FIG. 5. Three nephrocytes blocked by Indian ink. i. Indian ink particles, n. nucleus.

its middle. Like the branchial cavity the branchiae also diminish in size cephalad to get themselves accommodated inside. The branchial formula is given in the table.

TABLE

The Branchial Formula of *Caridina laevis*

	Appendages		Pleurobranch	Arthrobranch	Podobranch	Mastigobranch
1.	Maxilliped	1	0	0	0	1
2.	do.	2	0	0	1	0
3.	do.	3	1	1	0	1
4.	Pereiopod	1	1	1	0	1
5.	do.	2	1	0	0	1
6.	do.	3	1	0	0	1
7.	do.	4	1	0	0	1
8.	do.	5	1	0	0	0
			6	2	1	6=15

(The podobranch of the second maxilliped appears to represent the branchia and the epipod together, though not confirmed by embryological studies.)

The Structure of the Branchiae

The branchial axis is roughly triangular in cross section (fig. 3) and bears two rows of extremely thin gill lamellae. It has an outermost layer of thin cuticle. Inside the gill axis are three blood channels, two at the base of the triangle, the lateral branchial veins and one at its apex, the median branchial vein, separated by connective tissue cells. The blood spaces are without walls of their own and are bounded either by connective tissue or by the epidermis of the branchial axis. The boundary of the median branchial vein is more or less even whereas those of the lateral branchial veins are not. The lateral branchial veins are joined together by short connections throughout their length. Such a connection at the gill root is the largest of the series and the efferent branchial channel (branchiocardiac vein) which takes the oxygenated blood to the pericardium originates from this. Situated above and slightly lateral to the origin of the efferent branchial channel is the afferent branchial blood channel (fig. 4) which joins the median branchial vein bringing blood from the ventral thoracic sinus to the gills. The upper region of the wall of the gill root, with the cuticle and the epidermis dips into the afferent branchial channel at its origin and this tongue-like depression with the muscles attached to it, functions as a sort of regulator of the flow of blood from the ventral sinus into the gill (fig. 4). It is because of the working of the heart and the peculiar arrangement of the ostia that the blood is drawn from the pericardium to be conveyed to the various arteries. As the pericardium is directly connected with the gills by way of blood vessels viz. the branchiocardiac veins, it is this pull that is responsible for the propulsion of blood through the branchiae. Naturally the amount of blood flow through the gills may be determined by the rate of heart beat and since there does not seem to be any relation between heart beat and oxygen pressure of the water (Vide infra), it is likely that the regulation of the flow of blood is controlled by this tongue-like depression.

Structure of the Gill Lamella

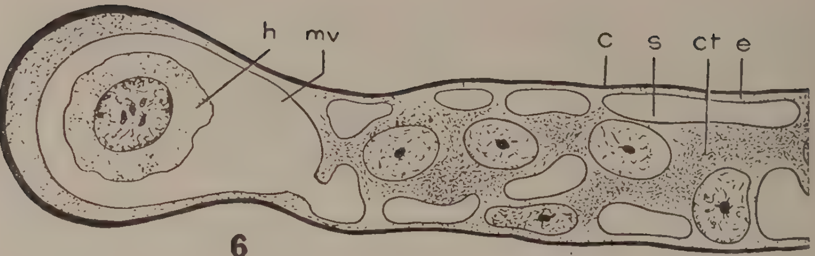
The lamella (fig. 5) is invested alround by a thin layer of cuticle, much thinner than the general cuticular layer of the body. The cuticle in the margin of the gill lamella is slightly thickened and forms a reinforcement, giving it rigidity. Below this is a thin epithelium. This represents the epidermal layer which has been reduced to the nature of a membrane with sparse nuclei. The lamella by itself measures only 19μ in cross section and naturally the epidermis, 4 to 14 μ thick elsewhere has to undergo extreme thinning to line the upper and lower sides of the lamella. Connecting the lateral branchial veins with the median branchial vein is the marginal vein, situated below the thickened cuticular rim. The two layers of the epithelium enclose a thin sheet of cells, similar to the connective tissue in the gill axis, with large round nuclei. The cell boundaries of these cells are quite indistinct. Whether these are extensions of the epidermal cells or connective tissue extensions of the gill axis is not clear. The two surfaces of this middle layer have, between themselves and the epidermal layers, a branching system of thin and flattened blood spaces, the marginal sinuses. These have their connection to the marginal vein all along the marginal vein. Though too thin to admit a corpuscle, occasionally the sinuses get oval in section, having a corpuscle inside. The sinus sometimes has been seen to extend deeper into the middle sheath.

Only very little work has been done on the histology of the gills in Crustacea. In the available literature, the structure of the branchiae differs considerably among themselves. But for the general arrangement of the blood vessels, no comparison could be made between the branchiae of *Palaemonetes* (Allen 1813) and the present form. The two parallel limbs of the marginal vein of each lamella are not continuous in *Palaemonetes* but are connected together by a series of transverse sinuses. The ‘ transverse cells ’ and the ‘ clear cells ’ of the lamella are not represented as such in *Caridina*. The middle sheath of cells of the lamella of the present form might probably correspond to the transverse cells. The ‘ pillar-cell junctions ’ described by Smyth (1942) in *Carcinus* and Pike (1947) in *Galathea* and the canals through the cuticle also have not been observed. It is obvious that, with the above two forms, *Caridina* differs considerably with regard to the structure of the branchiae. The glands similar to those described in *Palaemonetes* have also not been observed inside the branchial axis in *Caridina*.

In *Palaemon*, according to Patwardhan (1937) the branchial circulation is as follows. The lateral branchial veins receive the venous blood through the afferent branchial channel from the ventral thoracic sinus. This is conveyed through the marginal channels of the gill lamellae and collects in the median branchial vein. The efferent branchial channel takes the blood from the median branchial vein to the pericardium. But the study of the course of blood circulation in live specimens of *Caridina laevis* does not agree with this. Here the median branchial vein receive blood from the ventral thoracic sinus and this is sent to the two apices of the gill axis. The blood passes into the marginal vein of the lamella and finally enters the lateral branchial veins. Through the efferent branchial channel it reaches the pericardium. In *Palaemon* direct observation of the course of circulation in live animals is hardly possible because of the toughness of the cuticle and therefore it may be possible that the course has been interpreted wrongly.

Nephrocytes

Some of the cells on the wall of the lateral branchial veins are large (15-18 μ) and have fairly large vacuoles which push the spherical nucleus to the periphery. The vacuoles in unstained preparations contain yellow concretions. These cells are of the nature of nephrocytes and have been found to be blocked by Indian ink, as the amoebocytes in *Rhodnius* (Wigglesworth 1955). 0.5 cc. of filtered stick ink



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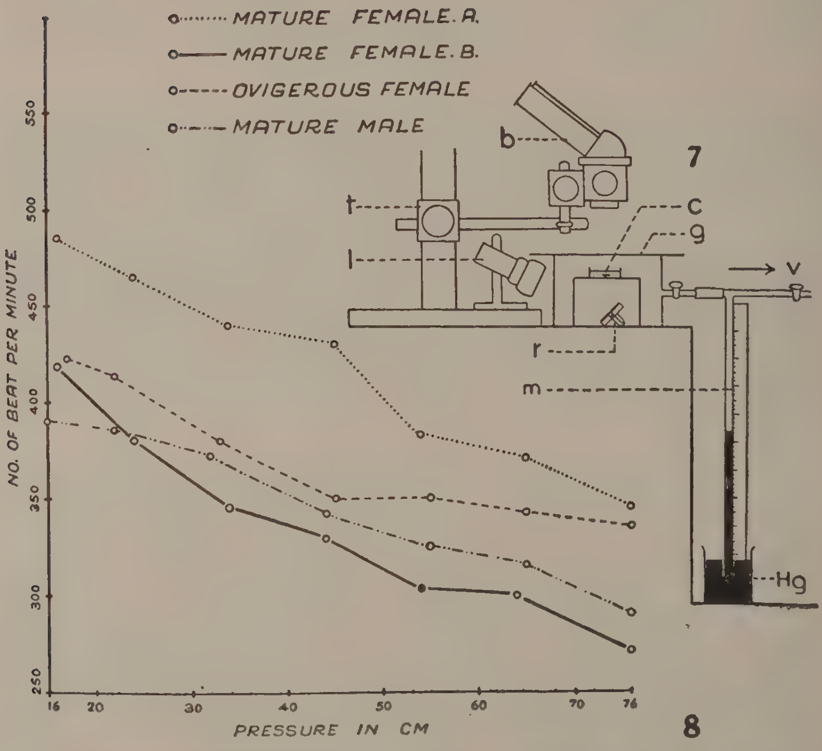

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FIG. 6. Transverse section through gill lamella. mv. marginal vein. Other letters as in figure 3.

FIG. 7. An illustration of the experimental device used for the study of respiratory regulation. b. binocular microscope, c. animal in petri dish, g. glass plate, Hg. mercury, l. electric lamp, m. manometer, r. reflector, t. stand, v. vacuum pump.

FIG. 8. Graph showing the inverse proportion between the oxygen content of the wate (plotted in pressure) and the number of scaphognathite beats.

boiled in Ringer solution was injected into the animal through a fine glass capillary. Injected animals were fixed later, sectioned in paraffin and examined unstained. In the blocked nephrocytes (fig. 6) the ink appears unorganised in the cytoplasm. Later, these seem to be assembled inside vacuoles of different sizes and shapes.

Nephrocytes more or less of the same nature have been described by Kowalewsky (1889), Allen (1893), Pearson (1908) and Pike (1947). How these accumulated substances are finally eliminated is not clear. In *Galathea*, Pike (1947) observed the contents as leaving the cell at period of ecdysis into the haemolymph. But the actual fate seems to be obscure. Smaller vacuoles containing ink have been observed in nephrocytes that have ceased to be attached to the wall of the lateral branchial vein. The probable fate of these in *Caridina* is as follows. When the vacuoles get filled, the nephrocytes expand and are then detached. The nuclei undergo disintegration as shown by the development of refrangible bodies inside. The boundary of the cell and its vacuole now gets ill-defined. It is possible that the contents of the vacuole now diffuse into the cytoplasm of the nephrocyte judging from the more or less uniform nature of ink distribution. Fragments of the cells are carried about and brought to the blood sinuses of the antennal gland. Unstained sections of the antennal gland fixed six days after administering Indian ink, show that the blood sinus lying immediately between the lower wall of the bladder and the upper wall of the end sac harbour a large number of nephrocytes containing ink in various stages of disintegration. It appears that the disintegrating nephrocytes get accumulated here, in order to be ultimately eliminated by way of the end sac epithelium.

Respiratory Regulation

Based on Henry's law (Mee 1937) that the amount of a partly soluble gas dissolved in a liquid is directly proportional to the pressure to which it is subjected at a constant temperature ($m/p=K$), various air saturations were created by controlling the atmospheric pressure. Animals collected from different environments were observed under various oxygen pressures in water and their scaphognathite beats were recorded for a definite interval of time.

The experimental device, illustrated in figure 7 consists of the following: A vacuum trough connected through a manometer to a vacuum pump; an electric lamp, a reflector and a stereoscopic binocular microscope mounted on a movable stand. The experimental animal, contained in a small volume of water in a petri dish is placed on the top of a smaller inverted glass trough inside the vacuum trough with the reflector beneath. A small piece of loosely spread sanitary cotton is put in the water for the animal to cling to and facilitate continuous observation. The vacuum trough is covered over by a thick sheet of glass smeared with vaseline. The beam of light from the lamp is reflected directly on to the animal and the microscope is brought to position. The number of scaphognathite beats is counted by the help of a counter and computed to per minute. The readings are taken in normal and in various reduced atmospheric pressures. For every changed pressure, time is given for the animal to get acclimatised and an average of ten to fifteen readings are taken. Because of a definite rhythm and uniformity in the play of the appendage, it is not difficult to make a more or less accurate count of beats with a certain amount of practice. The result is plotted in the graph (fig. 8).

The respiratory regulation has been studied under different air saturations in many Invertebrates. Walshe-Maetz (1952) has shown graphically the amount of variation in the number of pleopod beats of various Crustacea in fresh water, brackish water and marine and terrestrial species and that the fresh water and brackish water Crustacea possess the maximum capacity for respiratory regulation than their semi-terrestrial allies.

It is evident from the graph that mature female specimens more or less at the same stage of development of the ovary, collected from two different environments, show different rates of scaphognathite beat for any particular pressure. This can be explained as follows: The one that lives in a small body of water (mature female A) with very little vegetation and plenty of other animals will have a lesser amount of oxygen content at its disposal, hence the increased frequency of beat, while the water in a large pool with plenty of water weeds has a greater air content. Hence there is a decreased frequency of beat (mature female B). But in both, with declining pressures and consequently with declining oxygen content, the scaphognathite beat mounts almost uniformly as represented by the almost parallel slopes. The respiratory control in other fresh water Crustacea (Walshe-Maetz 1952), shown by the steepness of the slope of the curve with declining oxygen content seems striking in contrast with *Caridina* where the slope of the curve is much less steep. The frequency of the working of the flagellum of the second maxilliped which assists the scaphognathite in the maintenance of a respiratory current of water becomes greater with decreased oxygen content. It has not been possible to correlate the heart beat with the oxygen pressure as it does not show any definite pattern.

SUMMARY

The morphology and anatomy of the branchiae have been described. The mechanism and course of the respiratory current have been studied which has revealed that the flattened exopod of the first maxilliped has no function other than closing the prebranchial cavity from below. The branchial circulation, studied in live animals has been shown to be quite different from that postulated by Patwardhan (1937) in *Palaemon*. An attempt has been made to study the functional role of nephrocytes by blocking them with Indian ink. An apparatus for the study of the relation between oxygen pressure of the water and the number of scaphognathite beat has been devised. For any particular pressure, variation in the frequency of beat has been observed in different animals and even between two animals of the same sex at the same stage of development, collected from two different environments and the reasons therefor suggested.

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STUDIES ON THE SHRIMP *CARIDINA LAEVIS* (HELLER)

IV. The Neurosecretory System

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INTRODUCTION

Apart from attributing a function of transmission of nerve impulses, that the nerve cells produce a secretion was demonstrated by Scharrer (1928) and other scientists thenceforward. Recently the neurons showing glandular properties have come into prominence and these have been described as neurosecretory cells by Scharrer and Scharrer (1954). Neurosecretory cells are distributed throughout the central nervous system of Crustacea. Localised clusters are arranged in the brain and the eyestalks (Bliss, Welsh and Durand 1954, Enami 1951, Durand 1956). The precise localisation of the source of the hormones and their influence on particular physiological processes have not been investigated fully. Passano (1951) has shown a hormone that is capable of inhibiting moult, synthesised inside the X-organ and Durand (1956) has shown that the 'type 2' neurosecretory cells are the source of the moult-inhibiting hormone. The neurosecretory cells have been mapped in a few Crustacea (Enami 1951 a, Bliss and Welsh 1952, Bliss, Durand and Welsh 1954, Knowles 1953, Durand 1956, Parameswaran 1956). These based on their size, shape and staining reactions have also been classified into separate Cell Types (Enami 1951 b, Matsumoto 1954, Parameswaran 1956, Durand 1956).

METHODS

The study of the neurosecretory system was carried out mainly by the help of cut material. The entire head was fixed in Bouin's fluid, Heidenhain's Susa and Zenker-formol. The brain and thoracic ganglia with the eyestalks were dissected out in fixing fluids and kept in the same for the required time. Out of these, it was found that Heidenhain's Susa was best suited as it gave clear pictures without shrinkage, while the brain fixed in Bouin's fluid was liable to shrinkage which obscured the details of the cell types. Sections cut at 5 to 10 μ were stained in Heidenhain's Azan, Mallory's triple stain, Heidenhain's iron haematoxylin and Gomori's chrome-alum-haematoxylin-phloxine (Gomori 1941 adapted by Bargmann 1949). The latter though extensively used in the study of vertebrate neurosecretory cells, did not give as clear pictures as Heidenhain's Azan. Surgical removal of the sinus gland as was carried out by Kleinholz (1947) in the cray fish is not feasible due to the minute size of the animal.

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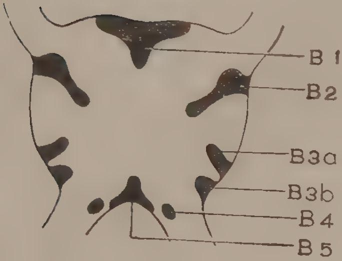

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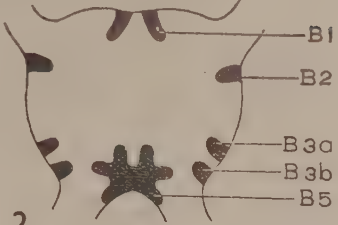

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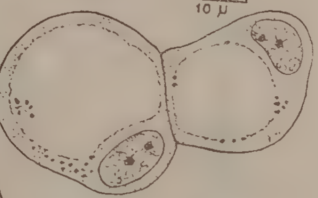

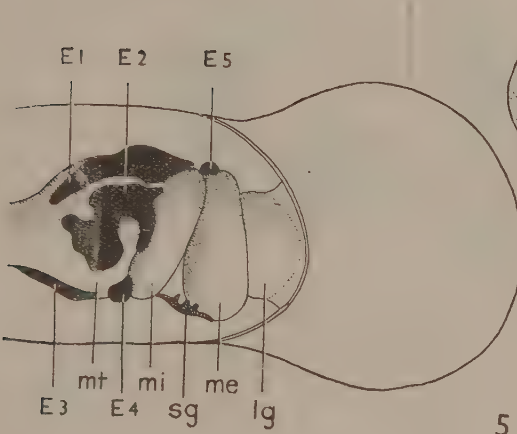

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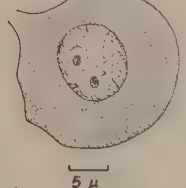

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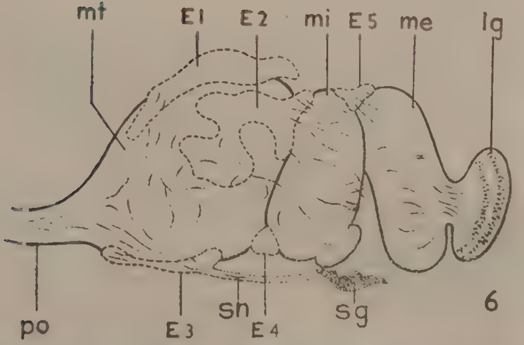

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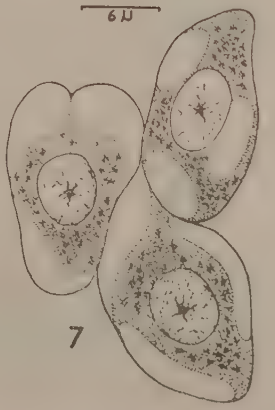

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Figs. 1 and 2. Maps showing distribution of neurosecretory cells in the brain ; dorsal and ventral views respectively. *B*1 to *B*5 represent areas of neurosecretory distribution.

Figs. 3 and 4. Neurosecretory cell of Type I from X-organ and brain respectively.

Fig. 5. Map showing the distribution of neurosecretory cell groups in the left eye. Dorsal aspect (Reconstruction). *E*1 to *E*5. Neurosecretory cell groups. *lg*. Lamina ganglionaris. *me*. Medulla externa. *mi*. Medulla interna. *mt*. Medulla terminalis. *sg*. Sinus gland.

Fig. 6. Optic centres, with secretion laden axonic fibres super-imposed therein showing their course. *po*. Peduncle lobus opticus. *sn*. Sinus gland nerve. (Other lettering as in fig. 5.).

Fig. 7. Neurosecretory cells of Type III form brain.

OBSERVATIONS

The maps showing the distribution of the neurosecretory cells for the brain and optic ganglia in *Caridina laevis* are represented in figures 1 and 2. In addition to these, neurosecretory cell groups have been observed in the stomatogastric ganglion and the ventral nerve cord. The stomatogastric ganglion which projects into the carotid dilatation and bathed by blood is enveloped by a cluster of neurosecretory cells. The tritocerebral connective ganglion demonstrated a few neurosecretory

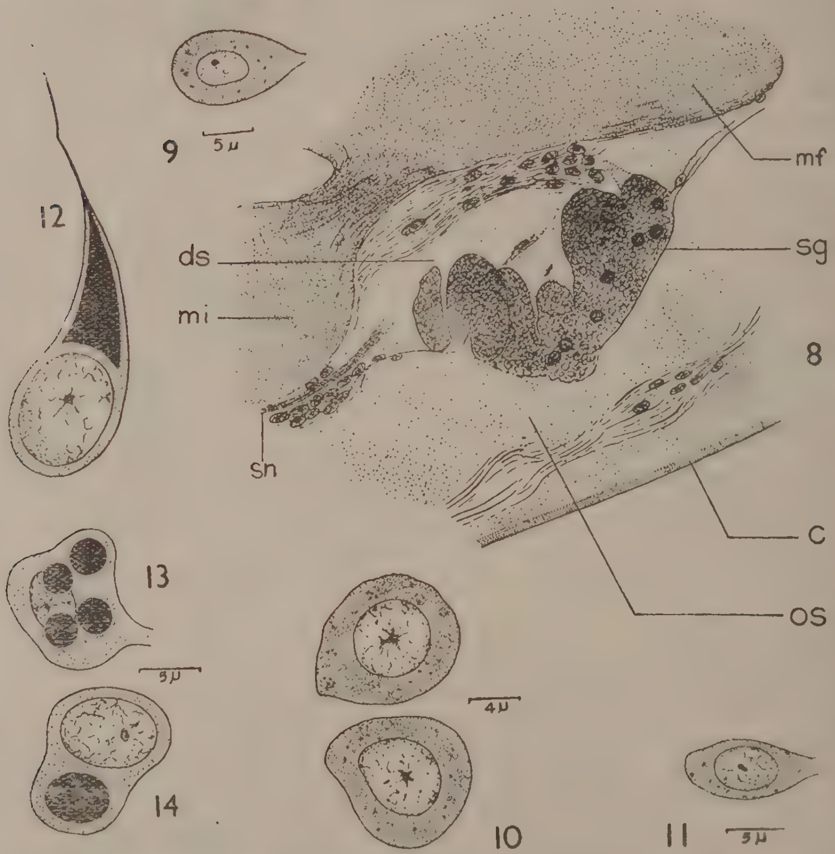

FIG. 8. Longitudinal section through sinus gland. *c*. Cuticular wall of the eyestalk. *ds* Dorso-lateral sinus. *os*. Outer optic sinus. Other letterings as in fig. 5.

FIG. 9. Neurosecretory cell Type III from brain.

FIG. 10. Neurosecretory cell from stomatogastric ganglion.

FIG. 11. Neurosecretory cell Type IV from eyestalk.

FIGS. 12, 13 and 14. Neurosecretory cells of Type II from X-organ showing secretory droplets in the cytoplasm.

cells on its median aspect. The 17 pairs of ganglia of the ventral nerve cord are also surrounded by neurosecretory cells.

The Sinus Gland (Figs. 5, 8)

The sinus gland is situated on the dorso-distal part of the eyestalk between the medulla externa and medulla interna which position has been noticed to shift usually towards the proximal part. It is formed as a differentiation of the epineurium and encloses the dorso-lateral blood sinus which communicates with the outer optic sinus. The sinus gland is 95 μ long and is 15 μ thick. Where the secretory product is sparse, fine striations of an eosinophil nature are noticeable. In others the syncytial wall of the sinus gland is laden with secretory droplets stainable red, blue or lilac in Heidenhain's Azan. The nuclei are placed more towards the outer side and are small and quite similar to the nuclei of other nerve cells. It is innervated from the medulla terminalis through the axons of which the secretory products from many neurosecretory cells could be traced as ultimately reaching the sinus gland which is looked upon as a storage depot.

X-organ

Hanstrom (1931) first detected the X-organ in Crustacea and has put forward the hypothesis that it represents the transformed sensory cells of a rudimentary eye papilla, which has taken on a secretory function (1939). Though strictly derived from sensory cells and not from true ganglionic cells, they are considered as neurosecretory cells.

The X-organ (figure 5 E1) constitutes a few clusters of cells lying on the ventral aspect of the eyestalk between the medulla terminalis and the medulla interna and extending as far as the peduncle lobus opticus. The X-cells are larger than the ordinary nerve cells and are arranged around the nerve starting from the proximal end of the medulla terminalis and innervating the rudimentary sensory papilla. Some of the cells constituting the X-organ are incretory in that they have been found to develop secretory granules stainable red in Azan and Mallory's, and blue in Gomori's chrome-alum-haematoxylin-phloxine. Groups of larger spherical structures 2 to 3 μ across have been noticed inside many of the cells of the X-organ. Hanstrom (1939) has interpreted these as irregularly shaped spherical concretions of secretion.

Neurosecretory cell types

Durand (1956) has described 4 cell types in *Orconectes virilis*. The cell types found in *Caridina* more or less conform to these.

Cell type I (Figs. 3, 4)

These are very few and found in the distal portion of the X-organ and in the anterior cell group of the brain. Those in the brain measure about 23 μ across, with nuclei half their size. The cytoplasm is granular. This type of cells in the X-organ is seen to develop large vacuoles containing secretory granules and resemble the 'a' type described by Enami (1951 b).

Cell Type II (Figs. 12, 13, 14)

These are most numerous in the X-organ. They measure about 9 to 12 μ and contain large secretory droplets about 2-3 μ. The nucleus has a single nucleolus. More or less similar cells have been observed in other clusters in the eyestalk, especially in the proximal part of the group E2. They differ from others in having a slightly larger nucleus with usually a single large secretory droplet. In some cells the droplets are seen to be transported directly to the medulla terminalis through the axons and finally to the sinus gland.

Cell Type III (Figs. 7, 9, 10)

These cells have a variety of forms probably in connection with their different secretory phases. Some are typically tear drop-shaped ranging in size from 7 to 13 μ and have nuclei half the size with single nucleolus. Around the nucleus are numerous small vacuoles and secretory granules. The stomatogastric ganglion has this kind of cells only. Larger cells measuring about 17 μ and with usually a few large apparently void vacuoles have been observed in the brain. These cells have a very striking resemblance to the 'B' cells described by Matsumoto (1954) and Parameswaran (1956). It is not clear whether they fall into the cell type 3 of Durand (1956).

Cell Type IV (Fig. 11)

These cells are small, oval (6 μ by 10 μ), slightly larger than the ordinary ganglion cells and are grouped together in most of the neurosecretory clusters in the eyestalk (except the X-organ) and the brain. The nucleus almost fills the cytoplasm. Secretory granules are sometimes present in the periphery of the cytoplasm.

The neurosecretory cell map for the eyestalk is given in figures 5 and 6. They have been numbered according to that in *Cambarus* (Bliss, Durand and Welsh 1954 and Durand 1956). The incretory nature of these cells is judged from the demonstrability of stainable secretion in the form of granules and droplets in cytological preparations.

Mode of release of Secretion

The mode of discharge of secretion indicates an axonal transport. The fuchsinophil and eosinophil secretion has been noticed inside the axis cylinder in contradistinction to the light blue-stainable neuropile of the medulla terminalis. All the secretion laden axonic fibres from the X-organ, in a superimposed reconstruction, run more or less parallel towards the origin of the sinus gland where similar accumulation has been noticed. This, on the whole resembles the condition described in various Brachyura by Smith (1948) and Enami (1951). Passano (1952), by phase contrast microscopic studies has traced the spherical system of granules from the X-organ to the sinus gland nerve.

The axonic fibres of the neurosecretory cell groups of the eyestalk, E2 (distal lobe), E5 and possibly E4, enter the neuropiles of the medulla terminalis, medulla interna or the medulla externa independently and are clearly traceable as red tracts in the blue background. The pathways of secretory granules have been observed to cross each other in the region of the thick connective separating the medulla externa and the medulla interna (fig. 6). At the distal extremity of the lamina ganglionaris, a distal and a proximal accumulation of granules have been noticed. It is possible that these represent the terminations of the axonic fibres viz. the 'onion bodies.' From here, the granules are probably liberated into the blood vessels situated below the basal membrane of the compound eyes. A few of these red granules have been observed sticking on to the inner walls of the blood vessels.

Bliss, Durand and Welsh (1954) have studied the axonal transportation of secretion in the neurosecretory cells of *Gecarcinus*. Here all groups of neurosecretory cells including the X-organ have their axons traceable directly to the sinus gland as well defined fibre tracts. The course of the axons directly to the blood sinuses below the basement membrane of the compound eye in the cell groups E2, E5 and possibly E4 in *Caridina* is remarkable. Knowles (1950) has shown that the removal of the sinus gland without blinding leads to an immobility of the distal pigments of the eye in *Leander*. But the reflecting pigment of the eye continues to be affected in response to changes of illumination. This has been interpreted by him (1956) as due to an extra-sinus gland source of the reflecting pigment activator in the eyestalk. From the close association between the blood sinuses surrounding the reflecting pigment and the accumulation and release of secretory products from the apex of the lamina ganglionaris from this extra-sinus gland source, it may be presumed that these have a role in the humoral control of the reflecting pigments of the eye.

SUMMARY

Neurosecretory cell maps for the brain and the optic ganglia of the eyestalks have been constructed and the cell groups numbered. Four types of neurosecretory cells have been distinguished in *Caridina*, comparable to that in *Orconectes*. Axonal release seems to be the mode of transportation of secretory products. Secretion laden axonic fibres from a few cell groups in the eyestalk have been traced directly to the blood sinuses below the basement membrane of the compound eye. It is suggested that these might have a role in the control of the movement of the reflecting pigment in the eye.

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VERTICAL DISTRIBUTION AND GENERAL ECOLOGY OF SOME OF THE COMMON INTERTIDAL ORGANISMS OF THE NORTHUMBERLAND COAST[1]

By G. Seshappa

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INTRODUCTION

The horizontal distribution and vertical zonation of organisms on the seashore has engaged the attention of marine ecologists for several years. While numerous investigations in different parts of the world have thrown much light on the nature of this distribution and zonation, they have still not removed the need for more intensive as well as extensive studies on different coastal regions for a complete and correct understanding of these phenomena. A part of the exposed Northumberland coast was therefore studied from this point of view during the years 1946-48. General ecological observations were also made on the more common intertidal species of this coast.

The field observations were carried out during the period October 1946 to December 1947, the limits of distribution of the more common species being followed in selected areas throughout the year. The work was completed early in 1948 but publication was unfortunately delayed. Some important papers such as those of Stephenson and Stephenson (1949), Womersley and Edmonds (1952), Chapman and Trevarthen (1953) and Lewis (1955) have appeared subsequent to the completion of this work. The discussion in the present paper has accordingly been revised.

The investigation was made by using a modification of Colman's (1933) traverse method designed to include the advantages of that used by T. A. Stephenson and his colleagues (see Bokenham, Naugebauer and Stephenson, 1938, and Evans, 1947a and 1947b). Sections of the intertidal region were chosen in different parts of the bay extending from low water mark to well above all tide marks, and a number of reference points marked on the rock at known intervals. These points were then accurately levelled correct to one hundredth of a foot using known bench marks for the purpose. Profiles were constructed of the sections chosen and several yards of the shore on either side of each of the sections were examined in detail for the distribution of plants and animals. Scrapings of the rock were examined in the case of very small organisms. The heights of intermediate points along the sections and of points outside the sections wherever necessary, were determined by the use of (1) the reference points mentioned above, and (2) a good handlevel clamped on to or held against a levelling staff so as to slide vertically along it.

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[1] Condensed from part of a thesis accepted for the degree of Doctor of Philosophy of the University of Durham in June, 1948.

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The detailed survey was carried out on the rocky and boulder beaches of Cullercoats Bay. General observations were extended to other selected areas as far as Newbiggin Bay, 15 miles north of Cullercoats.

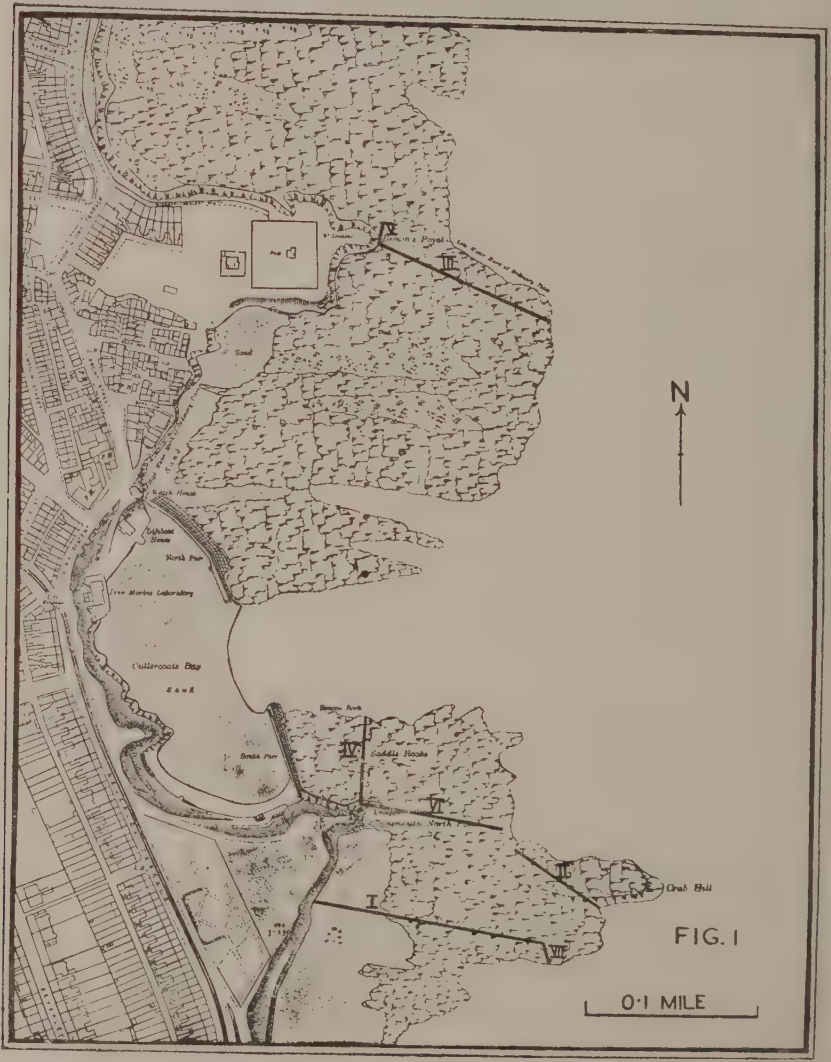


FIG. 1. Map of Cullercoats Bay and its neighbourhood showing the positions of the selected sections (I-VII) in the intertidal region.

The position and approximate directions of the selected sections are indicated in Fig. 1. The latter is taken from the Ordnance Sheet No. NLXXXVI. 5. (1919). The mapping of the sections was done by the Plane Table method.

Altogether seven sections were chosen so as to include as many different kinds of physical features as possible within the area surveyed.

In addition to these sections and the areas including them the South Pier was also levelled and its east face studied in detail. The remaining areas of the rocky, stony and shingly beach between the pipe-line section and the Brown's Point Sections were also periodically examined but not always with reference to accurate tidal levels.

GENERAL ENVIRONMENTAL CONDITIONS

(a) *Topography of the shore.*

The shore at Cullercoats is divisible into the ' North Side ' extending from the North Pier to the Brown's Point rocks, and the ' South Side ' extending from the South Pier to the southern end of Smugglers' Cave and Crab Hill rocks. Between these two parts, which are mainly rocky and boulder strewn, is the sandy foreshore guarded on both sides by the piers. In all these three parts, the shore is bounded on the landward side, except where artificial walls are built, by bare cliffs or ledges of rock or by clayey banks. Northward of the Brown's Point rocks the shore consists of rock and shingle for some distance and then passes over into the sandy beach of Whitley Bay. South of the Crab Hill and Smugglers' Cave rocks is a sandy beach extending for a considerable distance towards the River Tyne entrance. Sections I and VII are situated close to this sandy zone.

Crab Hill, on which section II is situated, consists of sandstone and is a continuous stretch of rock with a rough surface but without many boulders or large fissures. This rock is completely submerged at high tide but forms an island when the water reaches the level of Highest Low Water Neaps.

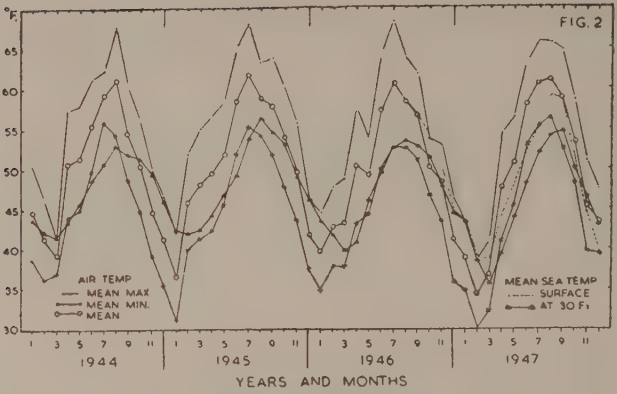
The Smugglers' Cave rocks are partly sandstone and partly limestone with a rough pitted surface. Sections IV and VI are situated on these rocks and parts of the areas traversed by these are covered by silt.

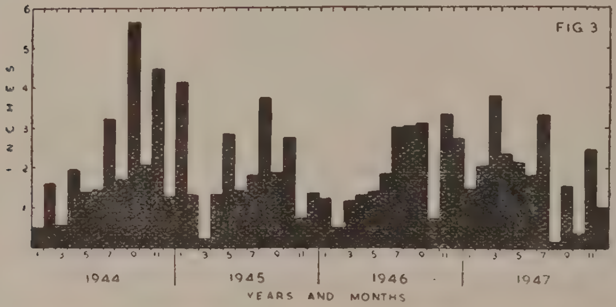
The Brown's Point rocks on the northside of the bay are of rough surfaced sandstone. Section III passes for the most part over the main rocks but partly also over a short zone of stones and shingle. Section V northward of Brown's Point, is for a short distance, on a continuation of the same rocks but has its main stretch in a region of boulders and shingle.

All these rocks are much exposed. Relatively sheltered spots are largely confined to the regions of boulders and stones which are less frequent on the Brown's Point rocks than on the rocks of the South side of the bay. A good part of Section VI is in an area which is the most sheltered in the upper shore of the bay.

(b) *Sea and air temperatures and rainfall.*

The intertidal organisms at Cullercoats are in general exposed to somewhat lower sea and air temperatures than in the south and west of England. Fig. 2 shows the monthly mean values of sea and air temperatures for the period 1945-47.





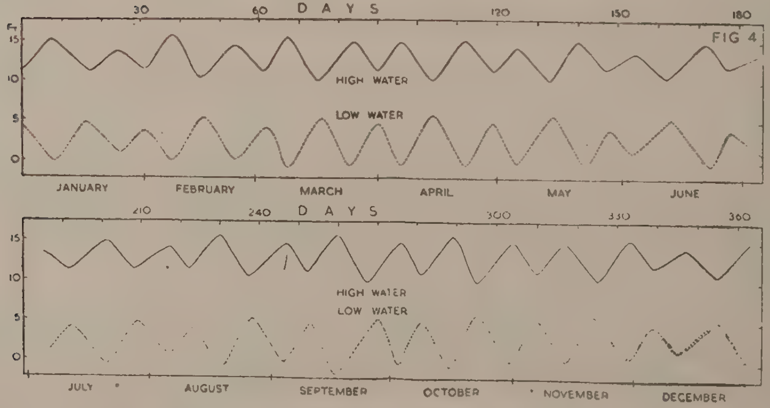


FIG. 2. Monthly sea and air temperatures at Cullercoats for the years 1944 to 1947.

FIG. 3. Monthly totals of rainfall recorded at South Shields from January 1944 to December 1947.

FIG. 4. Extreme tidal limits of all the tidal periods during 1947 showing roughly, the periodicity and frequency of continued submergence and emergence at the various intertidal levels.

Fig. 3 shows the rainfall data at Cullercoats (South Shields) for the same period.

(c) *Wind, Turbidity and Wave action.*

The prevailing winds are westerly. Both turbidity and wave action are important factors at Cullercoats and on the whole of the Northumberland coast on account of its exposed nature, the strong winds and the mainly sandy and muddy nature of the sea bottom near the shore.

(d) *Tidal levels and Exposure to the air.*

The tidal information has been taken or calculated from data given in the Admiralty tide tables for 1947 for the River Tyne entrance. Tidal levels were checked on several occasions with bench marks and were found to agree well with the predictions on calm days.

The theoretical range of the tide varies between 17.4 ft. and 4.1 ft. having a mean value of 13.84 ft. for spring tides and 7.09 ft. for neap tides. The Highest High Water and the Lowest Low Water both occurred on the same day in September and reached a height of 15.8 ft. and –1.6 ft. respectively; the Lowest High Water occurred in the months of September and October stopping at 9.9 ft. above C.D. (Chart Datum), while the Highest Low Water occurred in October and November and was 5.8 ft. above C.D. Low Water Springs at Cullercoats always occur early in the forenoon or during night and therefore, except during Summer, the effect of insolation is very low on the lower parts of the beach.

The terms ‘ Lowest High Water Neaps ’ and ‘ Highest Low Water Neaps ’ have been used here as equivalent to the terms ‘ Extreme High Water Neaps ’ and ‘ Extreme Low Water Neaps ’ used by Evans (1947a and 1947b). The latter terms are likely to be misleading as they might mean the ‘ Highest High Water Neaps ’ and the ‘ Lowest Low Water Neaps ’ respectively and therefore should be omitted.

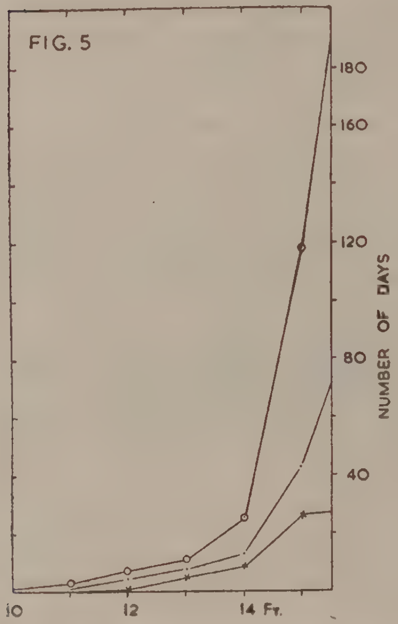
The percentage exposure to the air at different levels of the shore was calculated by Colman’s (1933) method. But instead of choosing exactly 380 hours for each period as Colman did, the full relevant tidal period is taken into account, beginning from the extreme tide immediately preceding the equinoctial date and ending with the similar next extreme tide.

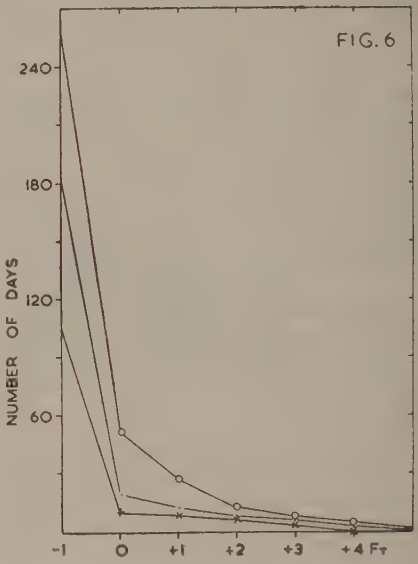
Colman (1933), Fischer-Piette (1936) and Chapman (1943) have drawn attention to the importance of ‘ non-tidal exposure ’ or continued emergence from water during the neap tide periods as one of the causal factors for critical zonational levels. This factor arises only above the level of the Lowest High Water Neaps and increases towards higher levels. But, as Chapman points out, it is not the regularity of the increase that is important but the significant changes at certain levels, in the rate of its increase. A method is suggested here for detecting these levels in this type of work : Fig. 4 shows roughly the lengths and frequency of such continuous emergence at various levels at Cullercoats. The figure is obtained by plotting against the days of the year the heights of the Highest and Lowest High Waters of all the tidal periods and joining them by a smooth curve, and gives a rough idea of the relative lengths of continued exposure at the various heights. The results are also shown in Fig. 5. The graph shows significant changes in the rate of increase between 13 ft. and 14 ft., and 14 ft. and 15 ft. above C.D.

Like the continued emergence factor is the continued submergence factor which is operative below the level of the Highest Low Water Neaps. The lower curve in

Fig. 4 is obtained like the emergence factor curve, by plotting against the days of the year, the heights of the highest and lowest low waters of all the tidal periods of the year and joining them by a smooth curve. The rough values thus obtained are plotted against intertidal heights in Fig. 6. The significant changes in the rate of decrease are here seen between – 1ft. and 0 ft., and between 0 ft. and +2 ft.

From Fig. 4 it is also possible to count the number of tidal periods in the year which reach their extreme limits at various heights on the shore.





5. Time of continuous exposure of various intertidal levels at Cullercoats during the year 1947.

6. Time of continuous submergence of various intertidal levels at Cullercoats during the year 1947.

DISTRIBUTION AND GENERAL ECOLOGY OF SOME OF THE COMMON ORGANISMS

(a) *General Remarks.*

The intertidal algae are comparatively poorly developed in the region studied, especially above the 'Laminarian Zone.' The fucoids are rather sparsely distributed and not very well grown. *Fucus serratus* is the most abundant and best developed; *F. spiralis* occurs only as patches of stunted plants and *F. vesiculosus* is also localised in its distribution; *Pelvetia canaliculata* is absent. Several normally common species of red and green algae are either unrepresented or are poorly grown and confined to particularly sheltered situations.

The fauna is also not very rich. Several common species are poorly represented and erroneous impressions of their vertical distributions would have been obtained if Colman's *limited* traverse method *alone* had been used for the survey.

(b) *Vertical distribution of the common species.*

The extreme limits of vertical distribution of the common species studied in the different sections is summarised in Tables I and II.

TABLE I

Limits of Distribution (in Ft. above C.D.) of some of the common organisms at Cullercoats. (Downward arrows indicate below and upward arrows above the levels given)

(a) ANIMALS

a	b	c		d		e		f	
No.	Species.	Sects. I & VII.		Sect. II		Sect. III		Sect. IV	
		U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.
	PORIFERA								
1.	*Grantia compressa* ..	1.4		—		2.9	↓1.5	2.8	0
2.	*Leucosolenia botryoides* ..	1.5		—		2.8	↓1.5	2.8	0
	COELENTERATA								
3.	*Actinia equina*	6.4	↓0	9.6	↓0	10.9	↓0	9.7	↓0
4.	*Dynamena pumila* ..	1.6	2.8	2.8		3.2	1.0	4.5	0
	ANNELIDA								
5.	*Fabricia sabella* ..	3.9		3.6	↓0	5.8	↓0	6.6	↓0
6.	*Pomatoceros triqueter*	5.0		2.6	↓0	4.9	↓0	5.1	
	ECHINODERMATA								
7.	*Asterias rubens*	1.5		0.8		1.6	↓0	—	
	MOLLUSCA								
8.	*Anomia ephippium* ..	1.5		—		4.1	1.0	3.1	0
9.	*Gibbula cineraria* ..	6.4		1.0	↓0	6.1	↓1.0	—	
10.	*Hiatella gallicana* ..	—		—		—		2.8	↓0
11.	*Lacuna pallidula*	—		—		7.3	1.0	7.2	↑0
12.	*L. vincta* ..	3.9		2.8		8.2	↓0	6.2	↓0
13.	*Littorina littoralis* ..	8.9		—		7.3	↓4.3	7.5	3.5
14.	*L. littorea* ..	11.5	↓2.1	9.9	↓1.9	10.8	↓2.3	14.0	0.9
15.	*L. neritoides* ..	12.4	4.2	9.9	1.9	24.5	3.9	21.9	5.2
16.	*L. saxatilis rudis* ..	11.9	2.1	9.9	9.7	15.3	3.8	14.5	4.9
17.	*L. saxatilis rudissina* ..	—		9.9	9.4	23.5	10.9	21.8	11.5
18.	*L. saxatilis saxatilis* ..	12.4	1.9	9.9	↓1.9	12.4	1.1	13.0	0.9
19.	*Margarites helicinus* ..	3.9		2.8	0	5.3	↓0	6.1	↓0
20.	*Mytilus edulis* ..	9.3		9.9	↓0	14.9	↓1.1	12.9	↓0
21.	*Nucella lapillus* ..	11.9	↓0	9.9	↓0	8.2	↓0	9.9	↓0
22.	*Patella vulgata* ..	9.7	0.7	9.9	1.0	16.9	1.1	13.4	↑0
23.	*Patelloida virginea* ..	1.4	↓0	1.5	↓0	2.4	↓0	1.4	↓0
24.	*Rissoa parva* ..	3.9	↓0	2.8	↓0	8.1	↓0	8.1	↓0
25.	*Turtonia minuta* ..	3.9		2.1	↓0	6.3	↓0	6.2	↓0
26.	*Zirfaea crispata* ..	2.2	↓0	—		—		—	
	CRUSTACEA								
27.	*Balanus balanoides* ..	12.4	1.5	9.9	↓1.0	14.9	1.0	12.2	↑0

No.	Species.	g		h		i		j	
		Sect. V		Sect. VI		South Pier		Extreme	
		U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.
	PORIFERA								
1.	*Grantia compressa*	—		—		—		2.9	↓0
2.	*Leucosolenia botryoides* ..	—		—		–		2.8	↓0
	COELENTERATA ..								
3.	*Actinia equina* ..	8.5	2.4	7.6	↓2.4	7.7		10.9	↓0
4.	*Dynamaena pumila* ..	—		3.5	2.4	—		4.5	↓0
	ANNELIDA								
5.	*Fabricia sabella* ..	—		5.6	↓2.4	—		6.6	↓0
6.	*Pomatoceros triqueter* ..	5.9	2.4	6.8	↓2.4	—		6.8	↓0
	ECHINODERMATA ..								
7.	*Asterias rubens* ..	—		2.4		—		2.4	↓0
	MOLLUSCA ..								
8.	*Anomia ephippium* ..	—		—		—		4.1	↓0
9.	*Gibbula cineraria* ..	4.8	2.4	6.9	2.4	—		6.9	↓0
10.	*Hiatella gallicana* ..	—		—		—		2.8	↓0
11.	*Lacuna pallidula* ..	5.3	2.4	8.2	2.4	—		8.2	↑0
12.	*L. vincta* ..	5.8	2.4	5.8	2.4	—		8.2	↓0
13.	*Littorina littoralis* ..	4.2	2.4	11.4	2.9	—		11.4	2.4
14.	*L. littorea* ..	3.1	2.4	11.4	2.4	10.1		14.0	↓0.9
15.	*L. neritoides* ..	24.5	5.8	19.9	13.0	20.8	6.3	24.5	1.9
16.	*L. saxatilis rudis* ..	15.8	2.4	8.5	5.9	16.8		16.8	↓2.1
17.	*L. saxatilis rudissima* ..	24.2	11.8	19.9	8.4	18.0	9.3	24.2	9.4
18.	*L. saxatilis saxatilis* ..	14.2	2.4	11.4	2.9	13.2		14.2	0.9
19.	*Margarites helicinus* ..	4.1	2.4	—		—		6.1	↓0
20.	*Mytilus edulis* ..	13.1	2.4	10.9	↓2.4	12.1		14.9	↓0
21.	*Nucella lapillus* ..	8.6	2.4	9.8	↓2.4	7.6		11.9	↓0
22.	*Patella vulgata* ..	16.7	2.4	14.1	2.4	14.6		16.9	↑0
23.	*Patelloida virginea*	—		—		—		2.4	↓0
24.	*Rissoa parva* ..	7.1	2.4	6.3	↓2.4	—		8.1	↓0
25.	*Turtonia minuta* ..	—		5.9	2.4	—		6.3	↓0
26.	*Zirfaea crispata* ..	—		—		—		2.2	↓0
	CRUSTACEA								
27.	*Balanus balanoides* ..	13.1	2.4	12.9	2.4	14.2		14.9	0

(c) *Seasonal changes.*

Some of the sections particularly Sections III and IV were closely watched throughout the year to determine possible changes in the limits of the vertical distribution of the different organisms from season to season ; general observations were extended to the other areas also.

There was no appreciable change seen in the case of most of the organisms. Most of the changes which did occur concerned the algae and were the result of the settling of a new generation of plants in the spring.

The following are the species which showed seasonal changes to a marked degree :—(1) *Porphyra umbilicalis*, (2) *Rhodymenia palmata*, (3) *Nucella lapillus*, (4) *Balanus balanoides*, (5) *Asterias rubens*, (6) *Enteromorpha compressa*, and (7) *Ulva linza*. The changes noticed in respect of the first four of these will be mentioned

TABLE II

Limits of distribution (in ft. above C.D.) of some of the common organisms at Cullercoats.

(b) PLANTS

a	b	c		d		e		f		g		h		i		j	
No.	Species	Sects. I & VII		Sect. II		Sect. III		Sect. IV		Sect. V		Sect. VI		South Pier		Extreme	
		U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L.L.	U.L.	L..L
	CHLOROPHYCEAE																
1.	*Enteromorpha minima* ..	18.3	5.4	—		16.9	10.9	18.5	11.5	18.2	11.5	18.2		21.1	10.6	21.1	5.4
2.	*Ulva linza* ..	—		—		6.5	1.1	8.5	3.2	7.5	2.4	8.1	2.4	—		8.5	↓0
	RHODOPHYCEAE																
3.	*Callithamnion sp.* ..	9.6		9.6		11.1		—		9.8	1.5	9.5	2.4	7.6		11.1	1.5
4.	*Chondrus crispus?* ..	2.4	0	1.5		1.1 & 13.7 ?	↓0 9.6	4.5		13.7 ?	9.6 ?	—		—		4.5 13.7?	↓0 9.6
5.	*Gigartina stellata* ..	2.0 - 1.1		2.8	↓0	8.2	↓0	6.1		7.0	2.4	6.3	↓2.4	6.3		8.2	1.1
6.	*Laurencia pinnatifida* ..	—		—		8.2		8.3		8.1	2.4	—		4.3		8.3 (opt.	↓0 5.9)
7.	*Lomentaria articulata* ..	—		—		8.2		8.3		7.9	2.4	—		4.0		8.3	↓0
8.	*Porphyra umbilicalis* ..	—		9.7	9.3	16.2	2.6	12.4	3.2	16.2	2.4	14.3	2.4	14.7		16.2	2.4
9.	*Rhodymenia palmata* ..	3.9		2.8	↓0	4.7		3.6		2.9	2.4	4.5	↓2.4	—		4.7	↓0
	PHAEOPHYCEAE																
10.	*Ascophyllum nodosum* ..	6.4	4.4	—		—		—		—		9.5	5.7	—		9.5	4.4
11.	*Fucus serratus* ..	3.9	1.1	2.8	↓0	9.5		9.4		4.6	2.4	8.7	2.4	5.8		9.5	-1.1
12.	*F. spiralis* ..	9.7	9.5	—		13.9	11.4	14.3	11.9	14.2	13.3	12.6	9.6	14.3	13.2	14.3	9.5
13.	*F. vesiculosus* ..	9.7	5.5	—		—		—		12.4	11.5	10.6	6.7	—		12.4	5.5
14.	*Laminaria cloustoni* ..	-0.7		0.3		0.1		0.8		—		—		—		0.8 -0.7	
15.	*L. digitata* ..	1.5		2.8		2.6		3.7		—		3.0		—		3.7	↓0
16.	*L. saccharina* ..	0.6		0.8		2.4		1.0		—		2.4		—		2.4	↓0

under the respective heads in the ecological accounts of the species. The changes relating to the rest are as follows :—*Asterias rubens*. The lower part of the pipe-line beach (area of sections I and VII) was kept under observation with particular attention to this species and it was found that while large numbers of *Asterias* occurred up to 1.5 ft. above C.D. during non-summer months, hardly any could be found above M.L.W.S. during August and September. It is probable that there is a downward migration of these starfishes from the littoral during the warmest months of the year. Similar summer migrations have been noticed in the case of *Asterias rubens* by Huntsman (1918) in Nova Scotia, and in *Pisaster ochraceus* and *Evasterias troschelli* by O'Donoghue (1924) in Departure Bay, British Columbia. Hewatt (1937) in Monterey Bay, found that ' a generally lower level is obtained by *Leptasterias aequalis* during the breeding season ' (late spring).

Enteromorpha compressa and *Ulva linza*. During the winter and early spring both these plants were absent from the rocks in most parts of the beach. By midsummer the plants had formed a dense covering on the rocks of the lower beach between M.T.L. and H.L.W.N. downward. Towards the higher levels the density was gradually lower, *Ulva linza* having its upper limit below L.H.W.N. while *E. compressa* occurred, though sparsely, to beyond M.H.W.N. Correlated with the appearance of the thick covering of these green weeds and of *Porphyra* on the lower beach was an elevation of the upper limits of distribution of *Rissoa parva*, *Lacuna vincta* and *Margarites helicinus*. Errant forms such as *Idotea granulosa* and amphipods not found on weed-free rocks in other seasons were also found now sheltering under these plants. By next December both the species had mostly disappeared.

(d) *Ecology of selected species of Plants and animals.*

(i) PLANTS

Fucus spiralis : This species forms not a dense belt, but a characteristic zone of sparse, stunted plants just below or within the *Enteromorpha minima* zone which forms the highest intertidal algal zone common to both exposed and sheltered rocks. Though nowhere abundant, a greater number of plants occur and thrive better where *E. minima* is absent. Of the local fucoids, *F. spiralis* is the most tolerant of surf action. It is associated with large populations of *Hyale nilssoni*, acarines, and of juvenile *Littorina saxatilis* (usually) and *L. littoralis* (occasionally).

F. spiralis ranges from just below M.H.W.S. to below L.H.W.N. Its most usual occurrence is between just below M.H.W.S. and M.H.W.N.

Ascophyllum nodosum : Cotton (1912), Rees (1935), Lyle (1920), Johnson and Skutch (1928) and Gibb (1939) report the species from both sheltered and exposed localities. Kitching (1935), David (1941) and Evans (1947a, 1947b) find that it prefers relatively sheltered localities. In Cardigan Bay, (David, 1941 and Evans, 1947a) it prefers a long, fairly level beach with shelter and surf. This seems to be the case at Cullercoats also. *A. nodosum* also seems to require a film of silt on the rock when the latter is very rough and rugged, as pointed out by Hatton (1938). It is nowhere found on steep slopes except when very well sheltered. There is a wide gap between *F. spiralis* and this species, probably because both are so sparsely represented, but, as David (1941) suggested (for Aberystwyth), the steepness of the shore at the higher levels (a feature which is common at Cullercoats and of which *F. spiralis* is tolerant) may be responsible for this. The same may explain the low upper limit of the species when compared with other areas. *F. vesiculosus* seems to mix freely with *Ascophyllum*, very often occurring on the same boulder.

The species extends from just below L.H.W.N. to just above M.L.W.N. and is more flourishing at the lower levels of its distribution than at the higher.

Fucus vesiculosus : This species is also poorly represented at Cullercoats, though better developed than *F. spiralis*. It is definitely much more tolerant of broken ground and boulders than any other of the fucoid species here. Kitching (1935) found on the Argyll coast that it survived on all slopes between 0° and 90°, was scarce and stunted on overhanging surfaces, and ranged from positions of the most extreme shelter to very wave-beaten coasts, frequently however, being sparse on the latter except when the shore was broken. He found that in sheltered parts *Ascophyllum* replaced *F. vesiculosus* though the latter was represented by a few plants at a higher level than *Ascophyllum*. David (1941) in Aberystwyth noticed signs of great competition between these two species ; he found that *F. vesiculosus* was frequently an epiphyte on *Ascophyllum* when it occurred above (E) H.L.W.N. and suggested that *F. vesiculosus* would grow higher up but for the crowding by *Ascophyllum nodosum*. This seems to be correct because, at Cullercoats, while both species are sparsely distributed, *F. vesiculosus* does occur at higher levels than *Ascophyllum* where the latter species is absent.

Fucus serratus : This is by far the best developed of the fucoid species of this coast. It is absent in highly exposed positions and unprotected steep slopes. Where it does not form a wide belt it may occur, but always patchily, in crevices or other places offering some protection. Kitching (1935) found it on the Argyll coast from wave beaten to very sheltered situations. Evans (1947a) in Cardigan Bay found that it definitely avoided steep slopes unless very protected but grew fairly well on boulders and was tolerant of fine sand ; on horizontal rocks the species was poor if surf was strong. This is also true for Cullercoats. Increasing shelter raises the upper limit of *F. serratus* to some extent. The range of optimum distribution of the species is variable according to conditions.

Laminaria digitata : Laminaria digitata occurs in both exposed and sheltered regions and the upper limit of distribution is lowered with increased exposure to surf. Evans (1947 b) describes this condition as being ‘ tolerant of a wide range of conditions of surf.’ It seems however, that where the upper limit of distribution is lowered and the plants are submerged almost continuously, they are not exposed to the action of surf although they are to that of backwash. These two forms of physical disturbance may be expected to have different effects on the plants.

Laminaria saccharina : This species comes next to *L. digitata* in its vertical extension and does not thrive in exposed situations. In very exposed places the species seems to be absent even in the regions (just below the low tide mark) of the backwash to which the surf effect is reduced in the case of submerged plants. The distribution of the species falls in line with the findings of Evans (1947 a & b) and Kitching (1935) in other localities.

Laminaria colustoni : According to Evans (1947a) in Cardigan Bay this species is more tolerant of exposed situations than *L. saccharina*. But here if we judge from its distribution above Low Water Mark, it is definitely less tolerant of exposed situations than *L. saccharina*. Its upper limit is below that of *L. saccharina* in all exposed situations where both occur. Both however, have about the same upper limits in some sheltered situations. In a more or less permanently submerged state this species is present in some of the exposed situations where *L. saccharina* is altogether absent, this showing perhaps a greater tolerance to the effects of backwash. The extreme upper limit noticed at Cullercoats was slightly above M.L.W.S. but only a few plants extended beyond 0.3 ft. above C.D.

Rhodymenia palmata : In many places this species forms a characteristic zone emerging above the *Laminaria* belt and is one of the commonest of the Rhodophyceae on the shore near the low water mark. It varies in size and intensity of colour being generally larger and darker in sheltered situations. It seems to be very tolerant of broken ground such as boulders and even small stones but is smaller in the latter case. In specially sheltered positions the region of maximum density lies at a higher level than elsewhere. The optimum limit of upper distribution is about half way between M.L.W.N. and M.L.W.S.

New young plants of *Rhodymenia* appeared in spring all over the lower part of the rocky and boulder beach and grew through the summer. The upper limit however, was the same as before, but by December, only the plants in sheltered localities and pools were surviving.

Porphyra umbilicalis : The history of this species also was closely followed throughout the year. In winter and early spring it was present mostly at high water mark (above L.H.W.N.). In June *Porphyra umbilicalis* appeared all over the beach in the lower regions also. By August it was very abundant, forming a characteristic covering to the rock, especially on the lower half of the beach along with *Enteromorpha compressa* and *Ulva linza.* On the Crab Hill and Smugglers' Cave rocks the new generation and the older generation which was found throughout the Winter months became one continuous zone though the new generation was always distinct because of its darker colour. On the Brown's Point rocks, there was a considerable gap left between the high water level forms and the newly settled low water level forms of *Porphyra.* By early December all the low water level forms disappeared on most of rocks. While the first appearance of the plants was noticed on the most exposed rocks, the first disappearance was also noticed in the same situations.

P. umbilicalis is tolerant of steep slopes and can stand very high exposure. But its distribution is always patchy and never in a dense or continuous belt. The low water form is more tolerant of broken ground than the high water form and much less tolerant of exposure.

The species is extremely tolerant of surf action and texture of substratum. It is frequently found with *Enteromorpha* spp. and often grows on limpet shells ; the low water forms sometimes occur as epiphytes on the fucoids. The winter form ranged between 16.2 ft. and 9.8 ft. above C.D. except on Crab Hill rock where it was found slightly further below L.H.W.N. The spring forms extended down to 2.4 ft. above C.D. and had their optimum upper limit just below M.T.L.

Gigartina stellata : This species occurs in variable quantities in all the areas studied and shows considerable tolerance to the nature and angle of slope of the substratum. On exposed rocks where *Fucus serratus* and *Laminaria* are absent or sparse, *G. stellata* is the dominant form forming along with *Chondrus crispus,* a characteristic belt of weed and silt with an optimum upper limit at a few inches above

M.L.W.S. In boulder regions it is mixed with *Rhodymenia palmata* and the *Laurencia-Lomentaria* community and becomes part of the underflora of *F. serratus* and *Laminaria digitata*. On exposed horizontal rock it does not extend much above M.L.W.S., but in sheltered situations under *Fucus*, in cracks and crevices, and on vertical surfaces it extends up to 8.2 ft., above C.D. (above M.T.L.) As a rule its occurrence above the M.L.W.S. level is patchy and never in the same density as below this level. In several situations the contour of the upper limit of *G. stellata* is found to follow closely the contour of the wash zone of the waves at this level and as the surf action is not the same at all points it seems likely that the emergence from water or the desiccation factor is the limiting cause for this upper limit.

Gigartina and *Fucus serratus* seem to be competing with each other for space as, in some sheltered places, the latter species is dominant and *G. stellata* becomes a member of the underflora. In other places which are very exposed *F. serratus* yields place completely or largely to *G. stellata*.

Enteromorpha : There are at least three species of *Enteromorpha* at Cullercoats, viz. *E. compressa*, *E. minima* and *E. intestinalis*. The first two are the more dominant and exhibit zonation, (on open rock). *E. minima* prefers rocks and boulders at the high tide level and forms a characteristic zone immediately above and including *F. spiralis*. It is tolerant of slopes, poorly developed in highly sheltered situations and absent on overhanging surfaces. There seems to be a close inverse correlation between the abundance of this species and of *F. spiralis*, the former being very sparse or absent where the latter is relatively well developed. The roughness or smoothness of the substratum also does not seem to matter much but it is most abundant on moderately smooth and sloping substrata. There is invariably a thin layer of silt in the *E. minima* zone with small nematodes forming the most abundant element of the fauna. In the recolonization observations (Seshappa, 1956) the development of some fucoid sporelings in the zone of *E. minima* and their later diminution in numbers indicated a possible competition between the two species. The optimum lower limit of *E. minima* is mostly near M.H.W.N.

E. compressa is also a very common species throughout the year in rock pools and on damp rocks, but is especially abundant during spring and summer. In some places no plants of this species were found on the rocks during March but by May they were appearing on the rocks and had increased in the pool both in exposed and sheltered situations. By June *E. compressa*, *Ulva linza*, and *Porphyra umbilicalis* together formed a characteristic zone in the lower littoral region. While *Ulva linza* and *P. umbilicalis* both disappeared in late autumn and early winter, patches of *E. compressa* continued to survive in sheltered places and moist localities.

Laurencia Pinnatifida : This species almost always occurs in association with *Lomentaria articulata*, occasionally including also patches of *Callithamnion* spp. and forming the *Lomentaria-Laurencia* community recognized by several authors (e.g. Cotton, 1912 ; Rees, 1935 ; Kitching, 1935 ; and Gibb, 1938 and 1939), as occurring on exposed and moderately exposed coasts. At Cullercoats *L. pinnatifida* is very common in exposed situations. Where present on flat rock it is always confined to crevices or underflora.

Callithamnion : Two species of *Callithamnion*, *C. arbuscula* (?) and *C. turneri* (?) occur at Cullercoats, sometimes mixed with *Laurencia* and *Lomentaria* but often independently and extending much higher in vertical distribution. *Plumaria elegans* is also sometimes associated with these two species. Like the members of the *Laurencia* group, *Callithamnion* prefers vertical surfaces and crevices at the edges of ledges. It is absent on small stones and not well developed on boulders ; the presence of silt does not seem to favour any of the species of *Callithamnion*.

Corallina : Both *Corallina officinalis* and *C. squamata* are present, the latter being the rarer and confined to lower tidal levels, occurring either amongst other weeds or singly. *C. officinalis* is more abundant on exposed rocks and extends up to M.T.L. In pools it goes higher up to M.H.W.N. and nowhere extends beyond this level. It is often found forming a characteristic patch on damp, silt-free, barnacle-covered rock ; but is also found in patches in silty areas occupied by *Fabricia sabella* and *Gigartina stellata*. The *Corallina* association is described as typical of exposed coasts (Cotton, 1912), replacing the *Laurencia* association when the surf is too intense for the latter. In Cardigan Bay (Evans, 1947a), it is one of the most tolerant of the littoral algae with regard to wave action. The distribution of *Corallina* at Cullercoats agrees with these findings.

(ii) Animals.

Balanus balanoides : The species is abundant in all the regions examined, subject to the occurrence of suitable local conditions and gives a characteristic appearance to the mid-beach, *Chthamalus stellatus* being absent. The ecology of this species in other places has been studied by several authors in the past, notably by Moore (1935 and 1938), Fischer-Piette (1929 etc.), Hatton (1938), Kitching (1935), Kitching and Moore (1939) and Evans (1947a and 1947b). It favours exposed rock irrespective of the angle of slope and, in the absence of surf, prefers regions most frequently washed by strong currents. The texture of the rock is important and although new spat are found to settle on practically every kind of surface available within tidal range, they thrive only on rough rock. The limits of vertical distribution are also affected by the amount of exposure or shelter in a given locality ; the upper limit is raised and the lower limit is lowered where there is much surf action thus increasing the intertidal range of the species ; conversely, the lower limit is raised and the upper limit lowered with increased shelter. The occurrence of silt and profuse weed is unfavourable to barnacles. All these points are easily verified at Cullercoats.

The vertical range of adult *Balanus balanoides* here lies between M.L.W.S. and M.H.W.S., stopping at and following closely the upper limit of the continuous *Gigartina* belt. There is in many places a clear upper barnacle line but this is often disturbed where *Enteromorpha minima* occurs. In such situations the upper limit of optimum density.is roughly about M.H.W.N. while elsewhere it may rise a little higher.

Nucella lapillus : *N. lapillus* is found in varying numbers in all the areas studied. Normally this species is most abundant in boulder-strewn areas and creviced rock, being very frequent in each case on vertical surfaces covered with barnacles.

Silty covering, smooth surfaces, and *Rhodochorton* or *Enteromorpha* beds are not frequented by *Nucella*, probably because of the absence of barnacles in these situations, and also the absence, frequently, of a firm foothold for creeping. Evans (1947a) says that the species is poor on the limestone rocks at Tinside, West Hoe in the Plymouth neighbourhood. Much of the rock to the north-east of the Smugglers' Cave is magnesian limestone and has a very small population of *Nucella*.

In vertical range *N. lapillus* extends from slightly above M.H.W.N. down to E.L.W.S. The abundance gradually decreases between M.L.W.N. and M.L.W.S. and not many are found below this latter level. During the season of barnacle settlement *Nucella* was found in numbers at all levels within the zone of dense barnacle populations.

Patella vulgata : This is one of the commonest animals on the shore. An account of its intertidal distribution with reference to size and sex frequencies at various levels on the shore at Cullercoats, has been published elsewhere (Das and Seshappa, 1947).

P. vulgata lives under conditions of extreme shelter as well as of extreme exposure to surf. In some sheltered localities however, especially below the mid-tide level, the density is low when compared with exposed situations at the same level. Coincident with this occurrence is a relatively better development of the larger fucoid and other weeds in such situations. Frequently also, in these localities quantities of silt combined with beds of *Rhodochorton rothii* etc. occur and these are unfavourable to *Patella*. Hatton (1938) noticed a denser settlement of *Patella* on exposed surfaces than on sheltered ones. Evans (1947b) suggests the filtering effect of the algal fronds must be important in this respect. While the presence of algae may be responsible for the scarcity of *Patella* in sheltered situations, an abundance of *Patella* may be responsible for the absence of algae in exposed situations, the two species thus having a reciprocal effect upon each other.

P. vulgata is very tolerant of the angle of slope and the texture of the substratum, occurring on rough as well as smooth and on overhanging as well as vertical and horizontal surfaces. Broken ground is tolerated up to a point. A rough surface seems to be essential for spat survival.

L. littorea : This is a shelter-loving species and when occurring on continuous rocky ground, is confined to horizontal and gently sloping surfaces and to the sheltered sides ; where weeds are relatively well developed or there is considerable amount of silt the number is relatively small. The species is not tolerant of fine grit or sand. The extreme range of vertical distribution is from about M.L.W.S. to M.H.W.S. No specimens were seen at E.L.W.S. anywhere and in most places the upper limit is reached round about M.H.W.N.

Littorina littoralis : This is the most shelter-loving and the least abundant of the Littorinids at Cullercoats. The scarcity of the species is correlated with the general scarcity of fucoid algae on the mid-beach.

The vertical distribution, like the horizontal, is also determined by the nature of the substratum and the degree of fucoid growth. The upper limit at Cullercoats lies at 1 ft. below L.H.W.N. and the lower limit between M.L.W.N. and M.L.W.S. The area of abundance lies in the neighbourhood of M.T.L.

Littorina saxatilis : This species was studied in some detail but an account of the same has however, not been included in this paper.

Littorina neritoides : This species occurs along with *L. saxatilis* in the ' Littorina zone ' and among the barnacles on exposed rocks in the ' Balanoid zone '. A peculiar feature is noticed in this species, especially on the Crab Hill. *L. neritoides* occurs as occasional individuals as low as 1.9 ft. above C.D., becomes more frequent above H.L.W.N., but occurs in numbers only in the crevices and among barnacles on the ledges near the top of the rock. The specimens at the lower levels look quite normal and have a well developed spire ; the colour is black or dark brown with sometimes a white streak on the last whorl. The specimens at the top on the other hand, are frequently stunted, with a rounded off spire and with an ash-grey colour. Search in similar situations elsewhere has also revealed the frequent occurrence of this peculiarity. The reason for this must lie perhaps in that *L. neritoides* shows an upward migration on the shore (Lysagt 1941). The young probably settle at all levels in the range of distribution of the species and all travel upwards to the *Littorina* zone which alone seems to be their proper *niche.* On Crab Hill, this upward journey of the snails is limited by the fact that the rocks do not extend beyond High Water Neaps. The snails, therefore, have to settle down at the highest levels available and may be affected in some way by continued daily submergence after their reaching adult size.

The zone of greater abundance of *L. neritoides* is above M.H.W.S. Evans (1947b) found specimens ' definitely ' below M.T.L. at Church Reef and down to M.L.W.S.+ 2 ft. at Blackstone Point. Lysagt (1941) found the species to below M.T.L. on Plymouth break-water. In Cardigan Bay Evans (1947a) found the zone of abundance to lie above M.H.W.S. ' though occasional specimens did occur as low as M.L.W.N.' During the present work, the lowest level at which specimens were recorded was 1.9 ft. above C.D. i.e. the lower limit may be said to lie between M.L.W.N. and M.L.W.S. The upper limit varies with the amount of surf and the nature of the rock and weed cover.

Gibbula cineraria : This species inhabits the stony and shingly areas near the low water mark. It is extremely shelter-loving and is completely absent on continuous rock ; even in the stony areas it is almost invariably found underneath the stones or in the sheltered crevices at their sides. Large masses of sand, fine silt and thick weed cover, are unfavourable. The optimum upper limit of distribution is about M.L.W.N. but occasional specimens do extend higher up, in highly sheltered situations.

Mytilus edulis : This is found in varying numbers in all the areas surveyed. The best population in Cullercoats, both from the number of individuals per unit area and the average size per individual, occurs on the top of the Crab Hill rock. While small individuals occur all over, down to low water mark, the larger sizes and numbers are restricted to situations where there is a considerable amount of surf-effect without much mechanical force.

In vertical distribution, *Mytilus edulis* may be said to extend from M.H.W.S. to below M.L.W.S. At the higher levels it is found only in moist crevices. The optimum distribution is variable from L.H.W.N. downwards.

General Discussion and Conclusions

(a) *Vertical Zonation :* The division of the seashore into a number of vertically disposed biological zones has long been recognized by marine ecologists, the zonation being most marked in the case of plants and sessile or semi-sessile animals. There is, however, considerable variation in the number of zones recognized and in the pattern of their arrangement from region to region and author to author (see for example, King and Russell, 1909 ; Pearse, 1913 ; Johnson and York, 1915 ; Hewatt, 1937 ; Stephenson, 1939 and 1949 ; Doty, 1946 ; Evans, 1947a, 1947b and 1949 ; Womersley and Edmonds, 1952 ; Ricketts and Calvin, 1952 ; Chapman and Trevarthen, 1953 ; and Lewis, 1953 and 1955). An excellent historical summary of the work on zonation is given by Ricketts and Calvin (1952).

In 1939, Stephenson suggested a fundamental plan of zonation for the British coasts in general, consisting of the ' Littorina ', ' Balanoid ' and 'Laminarian' zones from above downwards. Evans (1947a and 1947b) found it easy to fit the observed distribution of the intertidal organisms in Cardigan Bay, and the Plymouth neighbourhood into this plan. On the Northumberland coast, there appear to be (on a first examination), four clear zones namely, *Littorina*, *Upper Algal*, *Barnacle*, and *Lower Algal*. The distribution of organisms in these four zones would be as follows :—

(1) *Littorina Zone :* This corresponds to the *Littorina* zone of Cardigan Bay and Plymouth neighbourhood (Evans). It occurs from about M.H.W.S. upward and is characterised by *Littorina neritoides* and *L. saxatilis* var. *rudissima*. *Ligia oceanica* occurs in crevices. Lichens may be also present.

(2) *Upper Algal Zone :* This occurs roughly between M.H.W.N. and slightly above M.H.W.S. The zone is characterised mainly by *Fucus spiralis* and *Porphyra umbilicalis* (H.W. variety). *Enteromorpha minima* is an invariable component of the zone though this species may occur higher up also. *L. saxatilis* var. *rudissima* is characteristic on bare vertical cliffs. *Mytilus edulis*, *L. saxatilis* var. *rudis*, *Patella vulgata*, and *Balanus balanoides* also occur in varying densities where the algae are sparse or absent. At the lower levels are *L. littoralis*, *L. littorea* and *Nucella lapillus* penetrating into this zone in certain situations.

(3) *Barnacle Zone :* This occurs typically between M.H.W.N. and M.L.W.N. but may extend upward or downward at both ends according to circumstances. When the upper algal zone is not well developed, the *barnacle* zone and the *Littorina* zone may become contiguous. In extreme shelter, even the *Littorina* zone may be less prominent than usual as it would then get mixed up with the upper algal zone.

Balanus balanoides is the only barnacle occurring in quantities at Cullercoats and this with *Patella vulgata* gives a characteristic appearance to the mid-shore. The other important animals occurring in this zone are *L. saxatilis*, *L. littorea*, *L. littoralis*, *N. lapillus*, *M. edulis* and *Actinia equina*.

(4) *The Lower Algal Zone :* This is the lowermost part of the shore and is characterised by an algal growth of variable extent (with upper limit at about M.L.W.N. or lower) consisting of *Laminaria*, *Rhodymenia Palmata*, *Gigartina stellata*, *Laurencia pinnatifida*, *Lomentaria articulata*, *Fucus serratus* and *Corallina*. Practically all the species of animals mentioned for the *Laminarian* zone of Cardigan Bay occur here. In addition may be mentioned the sponges, various species of gastropods, bivalves and several other encrusting or sedentary forms.

The author's main arguments in favour of the above plan of zonation in preference to the three-zone plan are as follows :—

(i) The name *Laminarian* zone implies a relationship with species of *Laminaria* but is used to include regions of the lower shore beyond the upper limit of *Laminaria* itself. Species such as *Fucus serratus*, *Gigartina stellata*, and *Corallina*, sp. often extend far beyond the upper limit of *Laminaria*, and they are not restricted to the absolute lower limit of the barnacles. The term *Lower Algal Zone* would be appropriate as it would allow the inclusion of all species of the lower shore and provide also for all possible variations in the upward extent of the zone.

(ii) The occurrence of a belt of algae between the *Littorina* and the barnacle zones is found to be more a rule than an exception on the Northumberland coast, though the extent and density of this belt may vary. The absence of weeds in the upper shore can in most cases be correlated with peculiarities of rock configuration. It is natural therefore, to consider the occurrence of the upper algal zone as a primary condition while Evans considered that as a secondary condition in Cardigan Bay ; but even his basic plan itself indicates the presence of patches of algae in the lower part of the *Littorina* zone and the upper part of the *Barnacle* zone. The frequent references to algae in the upper shore in the literature and also the frequency of algae noticed by the author during casual examination of the upper shore in some places on the British coasts lead him to the belief that the existence of an upper algal zone must be considered a primary condition for the British coasts.

(iii) The ' Balanoid ' zone would include part of the upper algal zone in most places and the name would therefore lose its significance if it did not strictly refer to the zone of abundance in quantity. In Cullercoats this zone of abundance is often limited by the limits and densities of the algal belts both in the upper and lower shore. In high exposure, the algal zones may be highly reduced and the barnacle zone may be very extensive ; in high shelter, the reverse may happen.

In 1949, Stephenson and Stephenson introduced a new scheme, the *universal scheme* of zonation. This scheme, in essence, designates the regions above and below the effective intertidal belt of the shore as the *Supralittoral* and *Infralittoral* zones (the latter being actually a submerged zone), the effective intertidal region itself being divided into three zones called *Supralittoral fringe*, *Midlittoral* zone, and *Infralittoral fringe*, corresponding roughly to the *Littorina*, *Balanoid* and *Laminarian* zones respectively of the earlier fundamental plan (Stephenson, 1939 and Evans, 1947a). The Supralittoral fringe would extend from the upper limit of the Littorinas to the upper limit of barnacles in quantity, the midlittoral zone being marked by the latter above and the upper limit of the Laminarian or lower algal belt below. Some workers, notably Womersley and Edmonds (1952) have not been able to accept this scheme in full but many others, have found it easy to apply it in their surveys in different parts of the world. Mention may be made in this connection, of the works of Chapman and Trevarthen (1953), Guiler (1953), Lewis (1953and 1955) and Purchon and Enoch (1954). Even in the case of Womersley and Edmonds (1952), the Stephensons (see Lewis, 1955, p. 287) are satisfied that the difference is rather one of interpretation than of fact. The extensive work of Lewis (1955) on the British coasts has however brought out a point of difficulty regarding the identity of the upper limit of the midlittoral zone on some of these coasts, which becomes obscured by the presence of an algal belt or a bare zone which may sometimes be interpreted as midlittoral and sometimes as supralittoral. This is the difficulty noticed by the present author also, although in most situations on the Northumberland coast the upper algal belt is clearly above the barnacle line. Otherwise the present author also finds no difficultyin fitting the distribution of organisms on the Northumberland coast into the universal scheme. This coast must belong to the *Balanus*—type of zonation described by Lewis (1955, p. 273) and the upper algal zone will have to be considered mostly as part of the supralittoral fringe. This may not be so elsewhere but then the Universal scheme is meant to be so flexible and convenient that all such variations can be easily superimposed on the scheme.

(b) *Critical levels :* Apart from the gross pattern of vertical zonation discussed in the previous section, there is the question of the intertidal levels at which there may be sudden changes in the composition of the organisms both qualitatively and quantitatively. Such critical levels have been looked for and recognized by various authors in different localities (Colman, 1933 ; David, 1941 ; Evans, 1947 a & b ; Hewatt, 1937 ; Doty, 1946 ; and Chapman, 1943). Colman (1933) found three such levels in Wembury Bay, viz. between M.L.W.S. and E.L.W.S., between M.L.W.S. and M.L.W.N. and at L.H.W.N. (allowing in each case 2 ft. for splash). Evans (1947a) found five important levels in Cardigan Bay, but after a study of six localities near Plymouth in comparison with this locality, he (1947b) concluded that the positions of critical levels change according to local variations in surf-action, rock-configuration, illumination etc. Nevertheless, he considered the existence of critical levels an actuality and that in general, the following three regions of the shore might be described as more critical than others for organisms : (i) from M.L.W.S. (or just below this) to M.L.W.N. ; (ii) just below M.L.W.N. ; and (iii) from E. (lowest) H.W.N. to M.H.W.S.

In the light of these findings, the results from Cullercoats were also examined for the detection of critical levels by the method used by Colman (1933). The species considered are the same as in Table IV. Considering the data in the same manner as Colman did, it is interesting to notice from Table III that while there are two maxima for the lower limits of species on the shore, namely between -1 ft. and 2 ft. above C.D. and between 7 ft. and 12 ft. above C.D., as many as six maxima are apparent for the upper limits of species. The latter are at the following mean heights above C.D. : (a) 3.5 ft. (0.5 ft. below M.L.W.N.) ; (b) 5.5 ft. (1.5 ft. above M.L.W.N. and 0.3 ft. below H.L.W.N.) ; (c) 7.5 ft. (slightly below M.T.L.) ; (d) 9.5 ft. (0.4 ft. below L.H.W.N.) ; (e) 13.5 ft. (1 ft. below M.H.W.S.) and (f) 15.5 ft. (1 ft. above M.H.W. S.)

Table III

Number of species and limits of species in relation to tide levels in Cullercoats Bay. (Total number of species 43.)

Height rel. to C.D. in ft.	Lower limits	Upper limits	Total limits	Total species	Difference between Total Species and total limits
17-20	0	0	0	3	3
16-19	0	3	3	6	3
15-18	0	3	3	6	3
14-17	0	8	8	11	3
13-16	0	6	6	12	6
12-15	0	8	8	14	6
11-14	0	6	6	16	10
10-13	0	5	5	17	12
9-12	3	4	7	19	12
8-11	3	10	13	26	13
7-10	3	9	12	26	14
6-9	0	12	12	29	17
5-8	2	5	7	30	23
4-7	3	9	12	34	22
3-6	3	5	8	35	27
2-5	4	12	16	39	23
1-4	5	8	13	38	25
0-3	11	8	19	39	20
—1 to 2	12	1	13	36	23
—2 to 1	11	1	12	34	22

While some of the above maxima may be compared to those in the data of Colman and Evans there are others which have to be interpreted either as offshoots from the main maxima or as entirely new ones. One is tempted to feel that such a confusion might only increase if the number of species considered is also further increased. It is still possible however, to distinguish among the above levels some which are more critical than the others by a reference to the totals of both the lower and upper limits of the species. From this it is seen that the most critical level on the shore is at a mean height of 0.9 ft. above M.L.W.S. This mainly affects the lower limits of intertidal animals and plants. The next critical level is at a mean height of 0.5 ft. below M.L.W.N. and marks mainly the upper limits of a large number of sublittoral organisms. A maximum noticed at a mean height of 5.5 ft. above C.D. must be considered an offshoot from the previous maximum. The most critical level on the upper shore lies at about a mean height of 0.4 ft. below L.H.W.N., corresponding to the similar level in the data of Colman and Evans. The total species figures also justify this view. The maxima beyond this level are of minor importance but the minor critical level in the upper shore may be said to lie round about M.H.W.S. The maxima (e) and (f) of the upper limits can however, be related to the non-tidal exposure factor mentioned on page 171.

The zone of maximum survival of species is indicated by the difference between the total species and total limits and lies at a mean height of 0.5 ft. above M.L.W.N. This is therefore the least critical level for intertidal species. This corresponds to the least critical level revealed in Colman's work also but after allowing 2 ft. for the splash zone. Evans found the least critical level to be 1.2 ft. above H.L.W.N. at Cardigan Bay and to lie between H.L.W.N. and L.H.W.N. in all localities near Plymouth.

(c) *Relation of species to percentage exposure to the air :—*

Table IV summarises the recorded ranges of intertidal species in terms of percentage exposure to the air from Cardigan Bay (Evans, 1947b) and the Plymouth neighbourhood (Evans, 1947b) in comparison with the observed ranges of 43 species of plants and animals at Cullercoats.

The following points may be specially noted from the Table :

(1) In general the zonation may be said to be of about the same kind in all the three localities ; forms like *Fucus serratus*, *F. spiralis*, *Littorina saxatilis* and *Patella vulgata* are remarkably similar both in the absolute range and in the position of the upper and lower limits in all the three localities.

(2) Nine out of the twenty comparable species have considerably higher upper limits at Cullercoats than at Cardigan Bay. These are *Fucus vesiculosus*, *Gigartina stellata*, *Laminaria digitata*, *L. saccharina*, *Balanus balanoides*, *Gibbula cineraria*, *Littorina littorea*, *Mytilus edulis*, and *Nucella lapillus*. Of these the upper limits of *L. littorea*, *B. balanoides*, and *F. vesiculosus* are nearly the same at Cullercoats as in the Plymouth neighbourhood. The upper limit of *L. digitata* also is nearer that at Plymouth than at Cardigan Bay. As these species include both surf-loving and shelter-loving forms it appears that in both the extent of surf action and the degree of local shelter available Cullercoats and the Plymouth locality exceed the Cardigan Bay region. It is known that the surf-loving forms such as *Balanus balanoides*, *Littorina neritoides* etc., have their upper limits raised and lower limits lowered with

TABLE IV

Percentage exposure to the air, of organisms in Cullercoats, Cardigan Bay and Plymouth area.

No.	Species	Cullercoats		Cardigan Bay (Evans 1947a)		Plymouth area (Evans 1947b)	
		U.L.	L.L.	U.L.	L.L.	U.L.	L.L.
	PLANTS						
1.	*Ascophyllum nodosum*	57	28	71	15	83	10
2.	*Callithamnion* sp.	70	7	—		—	
3.	*Chondrus crispus*?	? H.W. 89)	58)	—		—	
		L.W.29)	0)	—		—	
4.	*Enteromorpha compressa*	84	0	—		—	
5.	*Ent. minima*	100	37	—		—	
6.	*Fucus serratus*	57	0	56	0	58	0
7.	*F. spiralis*	98	57	96	55	94	56
8.	*F. vesiculosus*	82	37	63	8	83	5
9.	*Gigartina stellata*	50	0	26	0	39	0
10.	*Laminaria cloustoni*	3	0	4	0	—	
11.	*L. digitata*	23	0	20	0	25	0
12.	*L. saccharina*	12	0	4	0	—	
13.	*Laurencia pinnatifida*	50	0	60	0	56	0
14.	*Lomentaria articulata*	50	0	—		—	
15.	*Porphyra umbilicalis*	100	12	100	0	—	
16.	*Rhodymenia palmata*	32	0	35	0	47	0
	ANIMALS						
17.	*Actina equina*	70	0	—		—	
18.	*Anomia ephippium*	26	0	—		—	
19.	*Asterias rubens*	12	0	—		—	
20.	*Balanus balanoides*	98	0	83	0	96	0
21.	*Dynamena pumila*	29	0	—		—	
22.	*Fabricia sabella*	43	0	—		—	
23.	*Gibbula cineraria*	44	0	21	0	33	0
24.	*Grantia compressa*	17	0	—		—	
25.	*Lacuna vincta*	50	0	—		—	
26.	*L. pallidula*	50	0	—		—	
27.	*Leucosolenia botryoidlis*	15	0	—		—	
28.	*Littorina littoralis*	73	0	81	4	85	2
29.	*L. littorea*	95	0	71	7	93	1
30.	*L. neritoides*	100	9	100	20	100	13
31.	*L. saxatilis rudis*	100	11)	100	8	100	7
32.	*L. sax. rudissima*	100	56)				
33.	*L. sax. saxatilis*	95	4)				
34.	*Margarites helicinus*	40	0	—		—	
35.	*Mytilus edulis*	99	0	61	0	—	
36.	*Nucella lapillus*	78	0	62	0	93	0
37.	*Patella vulgata*	100	0	100	0	100	0
38.	*Patelloida virginea*	12	0	—		—	
39.	*Pomatoceros triqueter*	44	0	—		—	
40.	*Rissoa parva*	50	0	—		—	
41.	*Turtonia minuta*	42	0	—		—	
42.	*Hiatella gallicana*	15	0	—		—	
43.	*Zirfaea crispata*	12	0	—		—	

increasing surf action. The more extended lower ranges of *L. neritoides* at Cullercoats would then suggest that this locality is even more exposed than Plymouth. Yet the elevation of the upper limit of *Gibbula cineraria* suggests a higher degree of local shelter also. Evans (1947a) suggests that the lower limit of *G. cineraria* at Cardigan Bay, when compared to Plymouth, may be due to the fact that the species is nearing the northern limit of its distribution. This obviously does not hold good as its upper limit at Cullercoats goes still higher in spite of the higher altitude. The sparseness of that species at Cardigan Bay may, on the other hand, be a more likely explanation.

(3) The ranges of *Ascophyllum nodosum* and *Fucus Vesiculosus* are much reduced at Cullercoats compared with the other two localities. This discrepancy must almost definitely be due to the scarcity of both these species at Cullercoats. It should be noted, however, that the distribution of these two species also differs to some extent between Cardigan Bay and the Plymouth neighbourhood. But the coincidence of the upper limits of *F. vesiculosus* between Cullercoats and the Plymouth neighbourhood is remarkable.

SUMMARY

(1) A detailed study was made, using a modification of Colman's traverse method, of the vertical and horizontal distribution of the common intertidal organisms in selected areas of the rocky and boulder beaches near Cullercoats.

(2) The general environmental conditions are described and the tidal data are analysed. A method is suggested for the calculation of the continued submergence and emergence factors.

(3) No appreciable seasonal changes were noticed in the limits of vertical distribution of most of the organisms studied.

(4) Some aspects of the general ecology and distribution of some of the common species of plants and animals are discussed.

(5) Four zones can be recognized in the intertidal regions of the Northumberland coast with reference to distribution of organisms, viz : *Littorina*, *Upper Algal*, *Barnacle* and *Lower Algal*. But these can be easily fitted into the Universal scheme of zonation (T.A. and Anne Stephenson, 1949), the *Upper Algal* zone being mostly part of the supralittoral fringe.

(6) The results of the study of the vertical ranges of 43 species of plants and animals are examined for critical levels on the shore and are compared with similar data available for Cardigan Bay and Plymouth neighbourhood. In general, the vertical distribution of organisms seems to be somewhat similar in all the three localities. There are three chief critical levels for the intertidal organisms at Cullercoats, viz. just above M.L.W.S., just below M.L.W.N., and just below L.H.W.N. The least critical level is between M.L.W.N. and H.L.W.N.

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SYSTEMATIC LIST OF THE SPECIES MENTIONED

(A) PLANTS

1. *Chlorophyceae.*
    - *Cladophora rupestris* KUTZ.
    - *Enteromorpha compressa* GREV.
    - *E. minima* NAEG.
    - *Ulva linza* AGARDH.

2. *Rhodophyceae.*
    - *Callithamnion* LYNGB. spp. (*C. turneri*? AGARDH and *C. arbuscula*? LYNGB)
    - *Chondrus crispus* LYNGB.
    - *Corallina officinalis* LINN.
    - *Corallina squamata* ELLIS.
    - *Gigartina stellata* BATT.
    - *Laurencia pinnatifida* LAMOUR.
    - *Plumaria elegans* SCHMITZ.
    - *Polysiphonia fastigiata* GREV.
    - *Porphyra umbilicalis* AGARDH.
    - *Rhodochorton Rothii* NAEG.
    - *Rhodymenia palmata* GREV.

3. *Phaeophyceae.*
    - *Ascophyllum nodosum* LE JOL.
    - *F. serratus* LINN.
    - *F. spiralis* LINN.
    - *F. vesiculosus* LINN.
    - *Laminaria cloustoni* EDMONDS.
    - *L. digitata* LAMOUR.
    - *L. saccharina* LAMOUR.
    - *Pelvetia canaliculata* DENE and THUR.
    - *Pilayella littoralis* KJELLM.

(B) ANIMALS

1. *Porifera.*
    - *Grantia compressa* (FABR.).
    - *Leucosolenia botryoides* (ELLIS and SOLANDER).

2. *Coelenterata.*
    - *Actinia equina* LINN.
    - *Dynamena pumila* (L.).

3. *Annelida.*
    - *Fabricia sabella* EHRENBERG.
    - *Pomatoceros triqueter* (LINN.).

4. *Echinodermata.*
    - *Asterias rubens* LINN.

5. *Mollusca.*
    - *Anomia ephippium* LINN.
    - *Gibbula cineraria* (LINN.).
    - *Hiatella gallicana* (LAMARCK).
    - *Lacuna pallidula* (da COSTA).
    - *L. vincta* (MONTAGU).
    - *Littorina littoralis* (L.).
    - *L. littorea* (L).
    - *L. neritoides* (L).
    - *L. saxatilis* (OLIVI).
    - *L. saxatilis* var. *rudis* (MATON).
    - *L. saxatilis* var. *rudissima* BEAN.
    - *L. saxatilis* var. *saxatilis* JOHNSTON.
    - *Margarites helicinus* (FABRICIUS).
    - *Mytilus edulis* LINN.
    - *Nucella lapillus* (LINN.).
    - *Patella vulgata* LINN.
    - *Patelloida virginea* (MULLER).
    - *Patina pellucida* (LINN.).
    - *Rissoa parva* (da COSTA).
    - *Skeneopsis planorbis* (FABRICIUS).
    - *Turtonia minuta* (FABRICIUS).
    - *Zirfaea crispata* (LINN.).

6. *Crustacea.*
    - *Balanus balanoides* (LINN.).
    - *Chthamalus stellatus* (POLI.).
    - *Hyale nilssoni* (RATHKE).
    - *Idotea granulosa* RATHKE.
    - *Ligia oceanica* (LINN.)
    - *Tigriopus fulvus* (FISCHER).

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ON A NEW SPECIES OF *NOTHRIA* MALMGREN (POLYCHAETA, ANNELIDA) FROM THE GULF OF MANNAR*

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INTRODUCTION

For the sake of convenience Hartman (1944, '59) justified the separation of the composite genus *Onuphis* Audouin and Edwards from the nearly related genus *Nothria* Malmgren by the presence of branched gills in the former and simple gill filaments in the latter. Both the genera are represented in the Indian waters although the seven species described from this area have been grouped under the composite *Onuphis* by Fauvel (1953) probably unaware of Hartman's review.

In a dredging done at 6 p.m. on 25-4-61 in the Gulf of Mannar opposite Pudumadam (79° 01′ E., 9° 16′ N.) at a depth of 4 metres, two complete specimens of polychaete worms of the family *Onuphidae* measuring 13.0 mm. (38 segments) and 8.0 mm. (25 segments) in length respectively, each living inside a peculiar, flattened tube measuring 14 mm. in length made of lamellibranch shell fragments (Fig. 4) were obtained. A critical examination of these two specimens reveal that they belong to the genus *Nothria*, but differ from the known species of *Nothria* in many features and as such is described here as *Nothria mannarensis* sp. nov.

In the course of this study we have been able to make a reappraisal of the description of an unnamed *Onuphis* species given by Monro (1931) collected by the Great Barrier Reef Expedition from Low Isles at a depth of 16.2 metres (9 fathoms) and find that this should belong to the genus *Nothria*. He could not attribute this specimen to any species with certainty but drew attention to its affinities with *N. conchylega* (Sars) and *N. macrobranchiata* McIntosh from Japan. Herein, we have discussed the status of Monro's *Onuphis* species in relation to *N. mannarensis* sp. nov. It is likely that when more material of *Onuphis* species becomes available it may have to be designated as a distinct species new to science.

Nothria mannarensis sp. nov.

Head rounded bearing five occipital tentacles mounted on short, ringed ceratophores with four annuli in each (Fig. 1) ; two pairs of eyes, the larger situated at postero-lateral base of posterior lateral occipital tentacles ; anterior minute pair at base of anterior lateral occipital tentacles ; posterior lateral tentacles longest ; median occipital tentacle about 4/5 of its length and reaching back to 4th setiger and antero-laterals half as long as median tentacle ; a pair of club-shaped frontal tentacles ; a pair of thick palpi on ventral side (Fig. 2) ; a pair of short tentacular cirri on an achaetous segment ; an achaetous anal segment with a pair of anal cirri (Fig. 3.).

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Mandibles consist of a pair of thin, elongated, distally expanded pieces, white in colour and calcified distally (Fig. 5) with inner medial corner black ; maxillae (Fig. 6) thin and slightly chitinized ; carriers longer than broad, basally pointed and black ; arrangement of maxillary plates on left side are as follows : Max. I falcate, without teeth, II with 9 teeth, III with 8 teeth and unpaired plate with 8 teeth ; on the right side Max. I is similarly falcate, without teeth, II and III with 9 teeth.

Gill unbranched, begins on 8th setiger as a small filament, shorter than dorsal cirrus (Fig. 9) ; at 10th setiger (Fig. 10) gill and dorsal cirrus are of same length ; posteriorly gill rapidly increases in length and dorsal cirrus decreases so that at 13th setiger former twice as long as latter and at 20th setiger former six times as long.

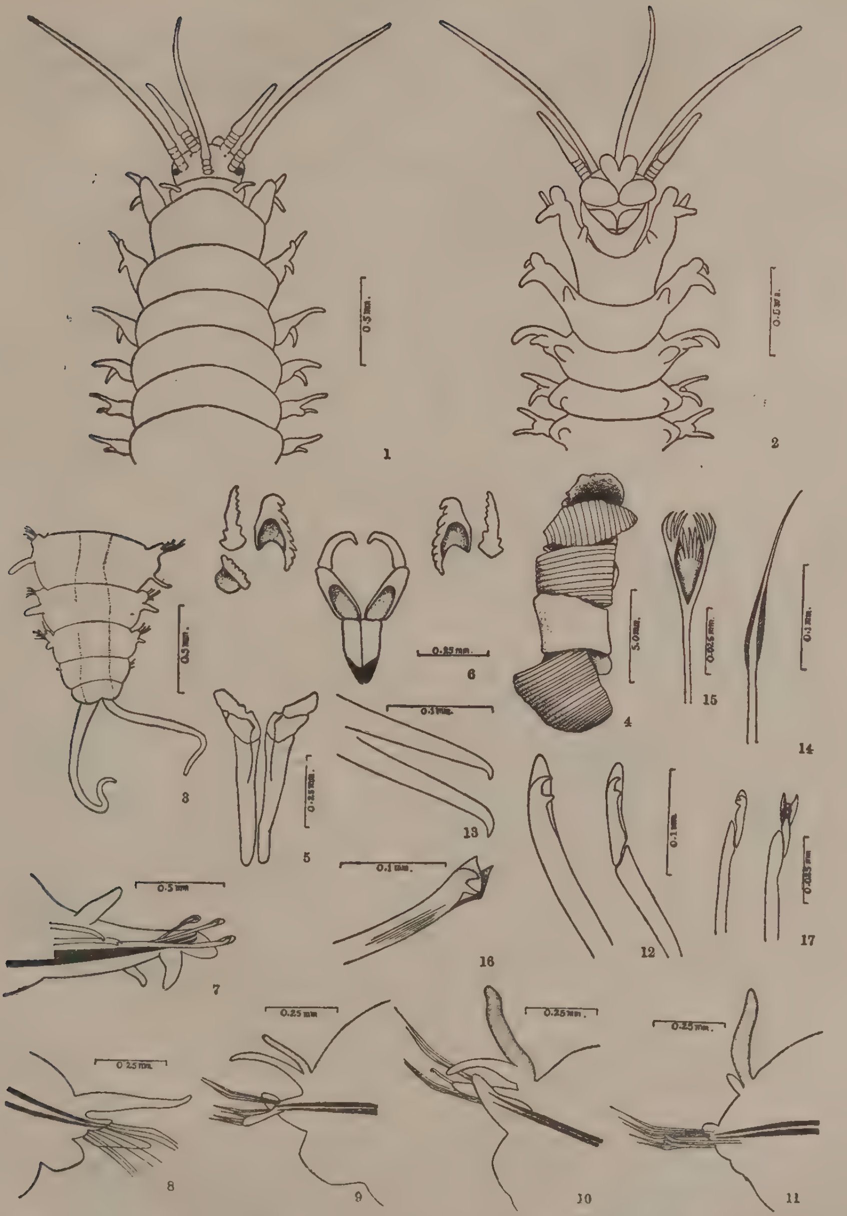
Parapodia of first and second setigers larger than succeeding ones and directed forwards, being situated at front edge of segment ; ends of first parapodia in level with tips of palps ; posterior pedal palps of first two parapodia elongated, ending in a small hood-like process covering hooks, and a stout ventral cirrus (Fig. 7) ; dorsal cirrus increasingly shorter from before backwards and are conical buds in hinder segments ; ventral cirrus cirriform in anterior segments, becoming shorter and thicker in succeeding segments until by 4th it becomes pad-like (Fig. 8) ; cirriform prolongation of posterior lip of parapodia becomes gradually shorter until by about 15th setiger from where it completely disappears (Fig. 11).

First two parapodia carry both compound, bidentate, hooded setae (600-640 μ long) and simple, bidentate, hooded setae (675-700 μ long) (Fig. 12) ; simple, capillary setae in 3rd and 4th parapodia ; bilimbate capillary setae (435-490 μ long) commence on 5th parapodia and present in all succeeding parapodia (Fig. 14) ; comb setae (135-145 μ long) with 16 teeth and edges turned inwards commence on 3rd parapodia and present in all succeeding parapodia (Fig. 15) ; 10th and succeeding parapodia except the last two carry two hooded, bidentate, subacicular setae (Fig. 16) in addition to bilimbate, capillary setae and comb setae; compound, bidentate, hooded setae (Fig. 17) present in last four parapodia ; two pointed, acicular bristles (725-760 μ long) in all parapodia with their tips bent in anterior parapodia (Fig. 13).

The animal upto the 9th setiger is transparent. The rest of the setigers present a brownish appearance, probably due to the dark brown mass found inside.

HABIT AND HABITAT

Instead of the flattened membranaceous tube coated with mud and shells in which the allied species, *N. conchylega* (Sars) is reported living, the present form inhabits a curious flattened tube, measuring 14 mm. long, made of broken lamellibranch shells cemented together (Fig. 4). The broken shell pieces forming the tube were identified as those of *Sunetta meroe* (Linn.), *Mactra mera* Reeve and *Glycemeris taylori* (Angas). The tube is lined inside longitudinally by a parallel row of sand grains in single file, thus forming a narrow groove in which the animal moves. The locomotion of the animal is very peculiar. The anterior half of the animal is thrust forward from the tube, the first two parapodia and their hooks get a firm hold on the substratum and the tube is pulled forwards by the contraction of the body. By repeating the above process the animal moves in short forward jerks.



FIGS. 1-17. *Nothria mannarensis* sp. nov. 1. Anterior part from the dorsal side. 2. Anterior part from the ventral side. 3. Posterior region, dorsal side. 4. Entire portion of the tube seen from above. 5. Mandible in ventral view. 6. Maxillary apparatus, dorsal view. 7. First parapodium in anterior view. 8. Fourth parapodium in anterior view. 9. Eighth parapodium in posterior view showing the gill filament. 10. Tenth parapodium in posterior view. 11. Fifteenth parapodium in posterior view. 12. Simple, bidentate, hooded seta and compound, bidentate, hooded seta from second parapodium. 13. Acicular bristles with bent tips from first parapodium. 14. Bilimbate, capillary seta from the ninth parapodium. 15. Comb seta from the thirty-second parapodium. 16. Hooded, bidentate, subacicular hook from the fifteenth parapodium. 17. Two views of compound, bidentate, hooded setae from the thirty-fifth parapodium.

The substratum from which the animals were dredged consists of coarse sand grains, shell fragments, numerous young bivalves and gastropod shells inhabited by hermit crabs. It is of interest to note that only flat shell fragments and not entire shells that form the covering of the animal.

Holotype : C.M.F.R.I. No. G.734/20. An entire animal measuring 13.0 mm. long and 1.0 mm. broad used for study.

Paratype : C.M.F.R.I. No. G.735/20. An entire animal measuring 8.0 mm. long and 1.0 mm. broad.

Type locality : Gulf of Mannar, opposite Pudumadam, 4 metres depth.

DISCUSSION

Of the 30 species listed under *Nothria* (Hartman, 1959) there are three categories (1) those with tridentate, hooded hooks (2) those with tridentate and bidentate, hooded hooks and (3) those with bidentate, hooded hooks only. *N. mannarensis* belongs to the third category to which *N. conchylega* (Sars), *Onuphis* species of Monro, *N. macrobranchiata* McIntosh (1885) and *N. lepta* (Chamberlin) are referable. In *N. lepta*, collected from the Pacific side of Panama from 1270 fathoms, the gill begins on the 6th setiger and continues upto the 53rd from where it disappears and unlike *N. mannarensis*, the first parapodium is not prolonged. Further the tube of this species is presumed to be of normal type (Monro, 1931). In *N. macrobranchiata*, the gill begins on the 9th setiger and the anterior, bidentate, hooks are described as simple. The affinities of the new species are more towards *N. conchylega* and *Onuphis* sp. of Monro (1931). In Table I the similarities and dissimilarities of these three species are clearly brought out. *Onuphis* sp. Monro (= *Nothria* sp.) is distinctly different from the closely related species, *N. conchylega* and *N. mannarensis*. Since the only specimen before Monro was incomplete (only 32, chaetigers) he left the species unnamed deliberately. His figure of the shell tube made of unbroken shells, measures nearly 21 mm. in length and the incomplete animal measures only 18 mm. in length. The entire specimen of *N. mannarensis* measuring 13 mm. possessed a tube 14 mm. long and as such it is reasonable to conclude that the maximum length of the entire specimen of *Onuphis* sp. described by Monro would not have exceeded 21 mm., the length of its tube. In view of this the setigers which Monro, unfortunately, could not describe would have been very few.

It is obvious from Table I and the foregoing accounts that *N. mannarensis* is markedly different from *N. conchylega* also, justifying the status given to the former as a new species.

Following the revision proposed by Hartman (1944) it may be seen that so far only two species of *Nothria* viz., *N. conchylega* and *N. holobranchiata* (Marenzeller) have been recorded from Indian waters (Fauvel, 1953). Both of these occur in the Gulf of Mannar. *N. mannarensis* is the third species now added to this list.

The appended key to the identification of the three species of *Nothria*, it is hoped, would be of help to future workers.

Key to the NOTHRIA *species described from the Indian waters*

1.	Gill begins on first parapodium.	*N. holobranchiata* (Marenzeller)
	Gill begins on 8-13th parapodia.	2
2.	Gill begins on 11-13th parapodia ; inner lateral occipital tentacle longest ; pseudoarticulate, bidentate setae in first two parapodia ; distinct membranous tube present.	*N. conchylega* (Sars)
	Gill begins on 8th parapodium ; posterior occipital tentacle longest ; compound, bidentate and simple, bidentate, hooded setae present in first two parapodia ; membranous tube absent.	*N. mannarensis* sp. nov.

SUMMARY

1. A small polychaetous annelid inhabiting a peculiar, flattened tube made of lamellibranch shell fragments dredged from the Gulf of Mannar opposite Pudumadam has been referred to the family *Onuphidae*, genus *Nothria* and described as a new species, *N. mannarensis.*

2. A round head bearing five occipital tentacles, posterior lateral being long, a pair of club-shaped frontal tentacle and a pair of thick palpi on the ventral side, two pairs of eyes, a pair of tentacular cirri on an achaetous segment, an achaetous anal segment with a pair of anal cirri, origin of gill as a short filament on the 8th setiger, first two setigers larger and pointing forwards, ventral cirrus becoming a pad-like structure on the 4th setiger, disappearance of the cirriform process of the posterior lip of parapodia on the 15th setiger, gill and dorsal cirrus of same length in 10th setiger, presence of compound, bidentate, hooded setae and simple, bidentate, hooded setae in first two setigers, bilimbate, capillary setae from the 5th setiger, two bidentate hooded subacicular hooks in the posterior segments and the presence of compound, bidentate, hooded setae in the last four setigers are the distinguishing features of this species.

3. The specific characters of the present form are compared with those of the hitherto known species under the genus.

ACKNOWLEDGEMENT

We have great pleasure in expressing our gratitude to Dr. S. Jones, Director of the Central Marine Fisheries Research Institute, for his kind encouragement and valuable suggestions during the course of this study. Our thanks are also due to Dr. E. G. Silas and Sri P. R. S. Tampi for carefully going through the manuscript and for offering valuable suggestions in the preparation of the paper.

TABLE I

	Nothria conchylega (Sars)	*Onuphis* sp. Monro (=*Nothria* sp.)	*Nothria mannarensis* sp.nov.
Eyes	Two pairs	One pair	Two pairs
Occipital tentacles	Inner lateral longest, reaching back to 8th setiger.	Median longest, reaching back to 11th setiger.	Postero-lateral longest, reaching back to 4th setiger.
Ventral cirri	Cirriform anteriorly, pad-like on 3rd setiger.	Pad-like on 6th setiger.	Cirriform anteriorly, pad-like on 4th setiger.
Gill	Begins anywhere from 10th to 20th setiger.	Begins on 9th setiger.	Begins on 8th setiger.
Size of gill	Not exceeding 1.5 times dorsal cirrus on 20th setiger (Fauvel, 1953, Fig. 128 e).	Equal to dorsal cirrus on 11th and longest on 25th, four times dorsal cirrus.	Equal to dorsal cirrus on 10th, longest on 20th setiger, six times dorsal cirrus.
First parapodium	Bidentate, pseudoarticulate setae or bluntly bidentate with no indication of articulation.	Compound, bidentate, hooded setae.	Compound, bidentate, hooded setae and simple, bidentate, hooded setae.
Second parapodium	3 pseudoarticulate, bidentate setae, 15-20 pectinate setae, 3 simple, limbate setae, and 2 obscurely articulate, bidentate, hooded hooks.	Compound, bidentate, hooded setae.	Compound, bidentate, hooded setae and simple bidentate hooded setae.
Third parapodium	Pseudoarticulate unbidentate setae	Capillary setae.	Simple, capillary setae and comb setae.
Fifth parapodium	?	?	Bilimbate, capillary setae and comb setae.
Median parapodium	Simple, pointed setae and 6 to 8 pectinate setae and 2 subacicular hooks.	Bilimbate, capillary, setae comb setae and a single, bidentate, subacicular hook.	Bilimbate, capillary setae, comb setae and two bidentate, hooded, subacicular hooks.
Subacicular hook	Two in number, bidentate, present from 13th setiger.	One, bidentate, present from 15th setiger.	Two, bidentate, hooded, present from 10th setiger (8th in paratype).
Posterior lip of parapodium	?	Disappears on 16th setiger.	Disappears on 15th setiger.
Tube	Greatly flattened, parchmentlike cylinder, covered above and below with shell fragments and flat pebbles.	Series of entire lamellibranch shells cemented together with their hinges at right angles to the long axis of tube; membranous cylinder absent.	Flattened tube, made of broken lamellibranch shells cemented together; membranous cylinder absent.

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DEVELOPMENT AND LIFE HISTORY OF A NUDIBRANCHIATE GASTROPOD *CUTHONA ADYARENSIS* RAO*

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Introduction

A general account of the habits, habitat and structure of *Cuthona adyarensis*, an aeolidiform nudibranchiate Gastropod of the Family Tergipididae occurring in the Adyar estuary was given in an earlier paper by the author (Rao, 1952). The present paper deals with descriptions of the gross structure of the early developmental stages of the embryos, the larvae and all further stages through which the free-swimming larvae of *Cuthona adyarensis* pass to attain the characteristics of the adult for an adaptation to a creeping mode of life. A very adequate information is available on the early development up to the formation of veligers in both the cladohepatic and holohepatic Nudibranchs from the works of Grant (1827), Alder & Hancock (1855), Reid (1846), Keferstein and Ehlers (1861), Casteel (1904), Rasmussen (1944 & 1951), Thorson (1946) and Rao & Alagarswamy (1960), but the changes which the larvae undergo to reach the adult condition are not fully understood. However, among the earlier workers Nordman (1846) in *Tergipes edwardsii* and Schultze (1849) in *Tergipes lacinulatus* and very recently Thomson (1958) in *Adalaria proxima* and Gohar and Abul-Ela (1959) in *Discodoris erythraeensis* had observed some post-larval developmental stages of Nudibranchs. The paucity of information on the subject is due to the reason that under laboratory conditions the larvae soon after hatching perish in enormous numbers in spite of the best care and attention and even a few that survive show no signs of further development. In the following account the methods adopted in obtaining successfully a complete series of developmental stages in *C. adyarensis* are described.

Material and Methods of Study

Full grown adults of *C. adyarensis* which measured about 12 mm. in length were obtained when they were found creeping on the floating algal masses of *Hypnaea* from the estuary of the Adyar river from March to August in 1948. When they were taken along with the algae and placed in the laboratory finger bowls holding dilute sea water they thrived well feeding upon the hydroids of the genera *Bimeria* and *Laomedea* which were found often on the algae and deposited strings of spawn after copulating at fairly frequent intervals. The finger bowls were wrapped in moist cotton gauze and placed in shallow enamelled trays holding ordinary tap water to a depth of about three-fourths of an inch, as a result of which the water contained in them remained at a temparature of 22°C to 24° C which was nearly 2 to 4°C below the room temperature. At the beginning water from the original habitat alone was used for keeping the animals or the spawn alive for observations, but subsequently sea water diluted with ordinary tap water to lower the salinity was found to be equally efficient. The salinity of water in the Adyar estuary ranged during the five month period from 20‰ to 38.47‰. The animals were found in fairly large numbers mostly during periods when the salinity was fair to moderately low between 20‰ to 28‰. Sea water after diluting to bring down the salinity to about 24‰ was tried and found suitable and this medium was continued thereafter during the period of observations. The finger bowls were cleaned and the water was changed twice a day at 10 a.m. and at 5 p.m. Freshly deposited spawn was periodically removed to separate finger bowls.

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For tracing the early development, bits of spawn were mounted in cavity slides in the medium of dilute sea water, covered with a cover-slip and examined either under the low or high magnification of the microscope. Rotating embryos and larvae were narcotised for camera lucida sketches by letting in a drop of 2% magnesium sulphate solution to each of the mounted preparations. Where the embryos were slightly opaque they were fixed in 1% glacial acetic acid and cleared in dilute glycerine.

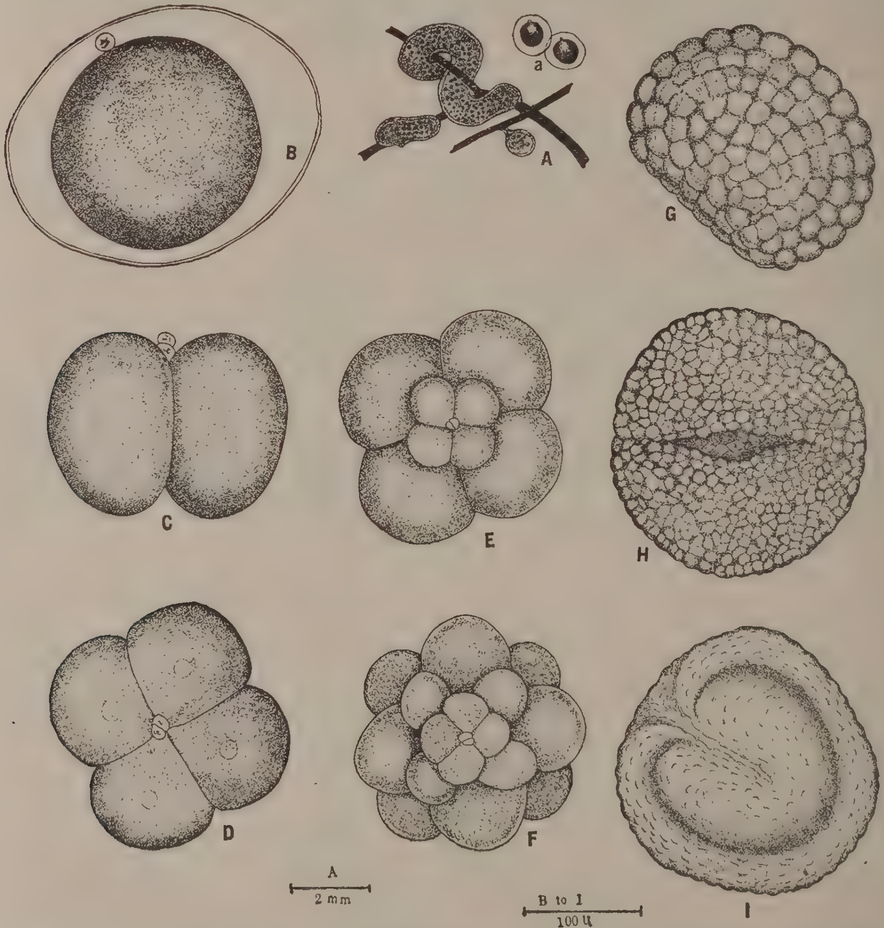
When the eggs had hatched, the contents of the entire finger bowls were examined under a binocular microscope, the larvae were then picked one by one by means of a pipette with a narrow drawn out nozzle and transferred to a separate finger bowl with freshly diluted sea water. The process which gave useful results, although very tedious, was repeated daily even after the creeping post-larval forms had made their appearance. The problem of feeding the post-larval stages of nudibranchs has been a difficult one as in the absence of the right type of food they soon perish. As it was noticed that the adults of the species take to minced brackish water anemones viz., *Phytocoetes* and *Boloceractis* under laboratory conditions, a few particles of the material was dropped once a day into the finger bowls and the post-larvae were observed to feed on them and grow well. All the creeping stages were narcotised in the same manner as the larval forms for microscopic observations.

Early Development upto the Formation of Veliger

Spawn.—The organs of reproduction, the act of copulation and the deposition of spawn have been described in a previous paper (Rao, 1952). The spawn is in the form of colourless mucous strings of varying length from a few to about 10 mm. or slightly more and of a diameter of 0.8 to 0.9 mm., with closely packed minute fertilised yellowish white eggs which lie encased in membranous capsules. The sticky mucous secretion as it extrudes out with the eggs through the female genital aperture hardens on exposure serving to fix the spawn either to the weed or to any other suitable material where it is deposited. Smaller masses of spawn are usually found attached by means of short mucous stalks (Text Fig. 1, A). Spawning in an individual starts half an hour to one hour after copulation and is continued several times at short intervals of a few hours each even without their coming together for a second time. Very young forms isolated when they were still immature and reared carefully under laboratory conditions grew to maturity and deposited spawn without pairing. As the adults are hermaphrodite with fully ripe sperms and eggs occurring simultaneously and as the placement of the male reproductive organs allows passage of the spermatozoa to the oviducal region, there is scope for self-fertilization of the eggs in an individual member (*vide* reproductive organs in *C. adyarensis*, Rao, 1952, p. 235).

Eggs in freshly deposited spawn.—The eggs in the spawn are semi-transparent, yellowish, spherical in outline and heavily yolk laden each measuring about 180 μ

in diameter. External to the yolk globules which are evenly distributed in the cytoplasm, there is an extremely delicate vitalline membrane. The egg is surrounded by a transparent albuminous fluid and enclosed in a double walled membranous capsule, which at first appears oval measuring about 270 μ by 220 μ. At the time of oviposition no polar bodies are usually present but nearly half an hour thereafter one polar body is extruded and it comes to lie on top of the egg (Text Fig. 1, B).



Text Fig. 1, A. Strings of spawn of *Cuthona adyarensis* deposited on weed ; (*a*) two of the eggs from the spawn viewed under low magnification ; B. freshly deposited egg after the extrusion of the first polar body ; C. two-cell stage ; D. four-cell stage ; E. eight-cell stage ; F. sixteen-cell stage ; G. side view of gastrula ; H. lower view of gastrula showing blastopore ; I. side view of gastrula showing the formation of the archenteric space.

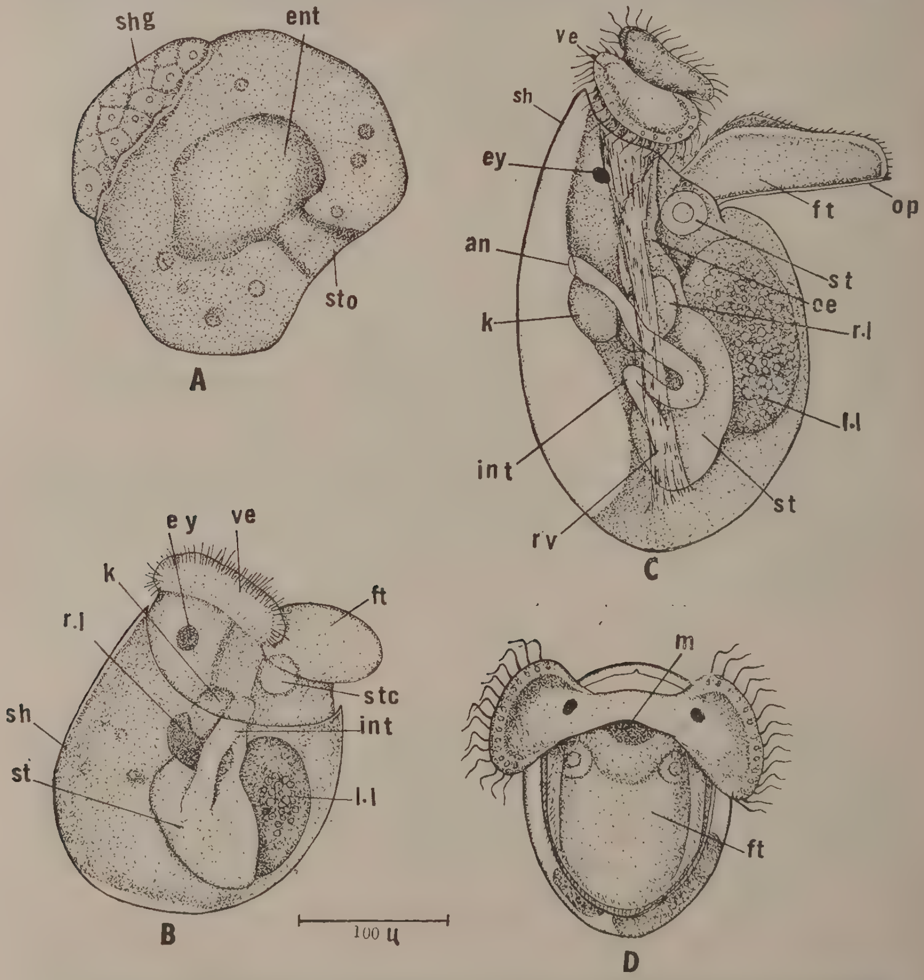
Early cleavages.—The extrusion of the first polar body is followed by the appearance of a second one, which is a little smaller and lies close to the former during the period when the egg undergoes division. About two hours after the deposition of the spawn the first cleavage which has a spiral trend divides the egg vertically into two equal halves. They are spherical to begin with but subsequently become a little elongated as they lie pressed to each other along the plane of the cleavage (Text Fig. 1, C). An hour later a second vertical cleavage which is laeotropic in character as in all molluscs appears at right angles to the first, dividing the egg into four cells (Text Fig. 1, D). About four hours after oviposition, a third horizontal cleavage appears resulting in four small micromeres lying on top of four large megameres (Text Fig. 1, E) and this stage is quickly followed by one showing sixteen cells (Text Fig. 1, F). While these cleavages are in progress, the capsule enclosing the egg assumes a rounded form instead of its being oval as at the time before the commencement of the division.

Gostrulation.—Subsequent divisions take place in quick succession leading at the end of eighteen hours to the formation of a mass of cells and at the end of twenty-four hours to an inverted cup-like gastrula by a process of invagination (Text Fig. 1, G). The gastrula, to begin with, has a height of about 170 μ and a diameter of 226 μ. The blastopore, which is a wide opening lies at the centre of the broad base (Text Fig. 1, H). Very soon the gastrula undergoes slight elongation, its height now being more or less equal to the diameter at the base with the apical region a little pointed. Next the archenteric space appears and the blastopore closes (Text Fig. 1, I).

Early veliger. A pit-like depression is formed at the region where the blastopore has closed giving rise to the stomodaeum which subsequently establishes communication with the enteron. Rudiments of the velar lobes and the foot make their appearance in the embryo dorsal and ventral in position to the stomodaeum respectively. In a shallow depression at the aboral region the shell gland appears and gradually spreads over the surrounding region like a cap. This stage in the developing embryo is attained in 28 to 30 hours after the deposition of the spawn (Text Fig. 2, A). About two hours after this stage the embryo begins to rotate within the capsule by means of cilia developed in the anterior region along the borders of the developing foot and the velar lobes.

In about forty-eight hours (Text Fig. 2, B) the formation of the shell (*sh.*) has progressed well, the velar lobes and the foot are better developed and the embryo rotates faster than in the previous stage. All other larval structures viz., a pair of dark pigmented eyes (*ey.*), a pair of clear statocysts (*stc.*), and oesophagus (*oe.*), stomach (*st.*), intestine (*int.*) and the right and the left liver lobes (*r.l.* & *l.l.*) have all appeared as in the corresponding early veliger stage of an ascoglossan Opisthobranch, *Stiliger gopalai*, described in detail by Rao (1937).

Veliger larva.—In seventy-two to eighty hours a veliger is fully formed (Fig. 2, C) with an elongate, inflated or ‘egg-shaped’ shell, a type characteristic of the members of the Nudibranch families, Flabellinidae and Tergipididae as contrasted with the ‘cup-shaped’ and ‘spiral’ types presented by the Duvacelidae and Polyceridae respectively (Thorson 1946). The veligers are not liberated free till the end of the fourth day, when the enveloping membranes of the capsules give way and the larvae wriggle out one by one into the surrounding water. The just hatched out larva is 370μ by 195μ. The shell is colourless and transparent with a smooth texture and a small aperture. The soft body is very slightly translucent and fairly bulky filling the major part of the lumen of the shell. The liver lobes are massive, the left lobe (*l.l.*) being very much larger than the right (*r.l.*) and the velum (*ve.*), though well developed, is small in proportion to the general build of the larva. The sub-velum is poorly developed. Ventral in position to the velar lobes is the foot, beneath which lies the operculum. The mouth opening, (*m.*) leads into the oesophagus (*oe.*) followed by a spacious stomach (*st.*) with which communicates a coiled intestine (*int.*) and is continued by a short rectum opening out into the mantle space by the anus situated dorso-laterally to the velar lobe on the right side. Close to the anus is a well



TEXT FIG. 2, A. Embryo of *Cuthona adyarensis*, *ent*. enteron, *shg*. shell gland, *sto*.sto modaeum; B. side view of the early veliger, *ey*. eye, *ft*. foot, *int*. intestine, *k*. excretory organ, *l.l.* & *r.l.* left and right liver lobes, *sh*. shell, *stc*. statocyst, *ve*. velum ; C. side view of the fully formed veliger just liberated from the capsule, *an*. anus, *oe*. oesophagus, *op*. operculum, *r.v*. retractor muscle of the velum, and the rest of labelling as in B ; D. larva in swimming position viewed from above, *ft*. foot, *m*. mouth.

developed greenish yellow vesicular excretory organ (*k.*). The liver lobes are greenish and laden with granular reserve material. The sense organs are presented by a pair of dark pigmented eyes each mounted on a small elevation dorsally behind the corresponding velar lobe and a pair of deep seated clear statocysts (*stc.*) each with a single otolith at about the root of the foot. The retractor muscle of the velum (*r.v.*) and those of the foot are present as in other Opisthobranch veligers (Rao, 1937, Casteel 1904 and Rasmussen, 1951). All the larvae are liberated free from a string of spawn by the end of the fifth day or the beginning of the sixth day and they swim about in water for a very short period, varying from a few to about twenty-four hours at the end of which they settle down and creep at the bottom.

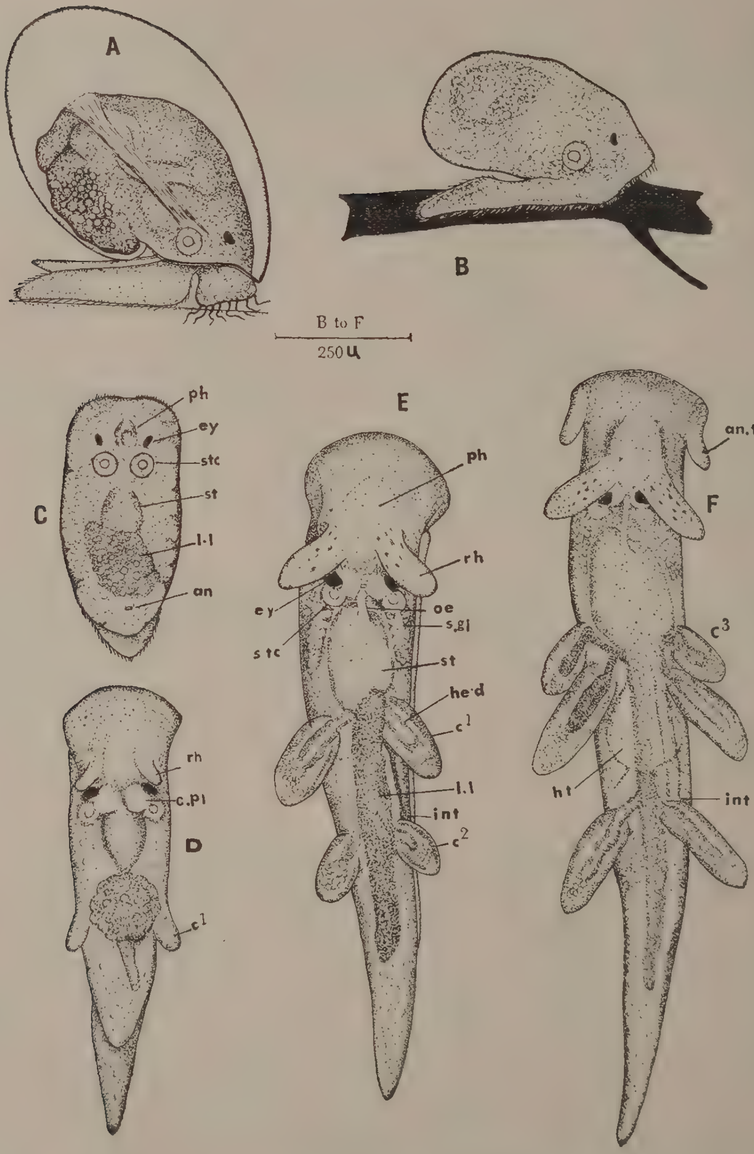
POST-LARVAL DEVELOPMENT LEADING TO JUVENILE STAGES

Earliest creeping phase.—During the brief free swimming existence, the larva frequently touches the bottom or settles on the weed and begins to take to creeping as shown in Text Fig. 3, A. Within a few hours thereafter, the velum is gradually reduced, the now ventral surface of the foot which had been its upper surface in the erstwhile free swimming phase has expanded to provide the sole to creep with and the shell which had helped for floating in water having become a hindrance to its new mode of life is discarded as the soft body wriggles out of it. The operculum is dropped more or less at the same time as the shell.

The earliest creeping phase in the development of *C. adyarensis* is a minute clumsy looking yellowish elongate or oval form 500μ long and 225μ broad. The anterior region is roundish with only a faint indication of the much reduced velar lobes. A small plumpy visceral mass lies over the flattened foot. Within the visceral mass are a pair of dark pigmented eyes, a pair of clear statocysts and an alimentary tract with a prominent pharyngeal bulb, an enlarged stomach and a large greenish bilobed liver mass. The mouth opening is anterior and median and the anal opening dorsomedian and a little anterior to the posterior extremity of the body. The pharyngeal bulb reveals the rudiments of the jaws and the radula. The tentacles and the cerata are absent and the form is found to move rather slowly (Text Fig. 3, B & C).

Post-larva with rudiments of rhinophores.—In about twenty-four hours after discarding the shell the postlarva presents an elongated appearance. The anterior extremity of the head region is rounded in its dorsal profile and it gradually slopes down a little backwards to reach the foot which is slightly rounded in front but tapering into a tail behind to a little distance beyond the posterior extremity of the dorsum. Two tiny blunt bud-like outgrowths which mark the beginnings of the rhinophores, corresponding roughly to about the middle region of the pharyngeal bulb make their appearance. Another pair of outgrowths also appear a laterally and slightly behind the middle region of the dorsum and these represent the first pair of cerata. In the region of the eyes and close behind them the cerebro-pleural ganglia appear through the transparent skin covering them. The anus is not exactly along the median line but slightly to its right. The post-larvae at this stage are translucent and almost colourless but for the dark pigmented eyes and they measure 818μ by 255μ (Text Fig. 3, D). They were observed to move very rapidly and to feed on fresh hydroids or on tiny particles of the flesh of brackish water anemones.

Post-larva with two pairs of cerata and ramifications of hepatic diverticula.—At the end of the next twenty-four hours the post-larva has reached a stage as presented in Text Fig. 3, E. It has an elongate form 123μ by 270μ with its anterior region slightly



Text Fig. 3, A. View of larva in creeping position before discarding the shell; B. post-larva immediately after dropping the shell and absorption of the velum, as viewed creeping on a weed; C. dorsal view of the earliest creeping stage, *an.* anus, *ey.* eye, *l.l.* liver lobes, *ph.* pharyngeal bulb, *st.* stomach and *stc.* statocyst; D. post-larva with primordia of rhinophores and cerata of the first pair, c^1, cerata, *c.pl.g.* cerebro-pleural ganglia, *rh.* rhinophores; E. post-larva with two pairs of cerata and ramifications of hepatic diverticula, c^1 & c^2. cerata of the first and the second pairs, *ey.* eye, *he.d.* hepatic diverticula, *int.* intestine, *l.l.* left liver lobe, *oe.* oesophagus, *ph.* pharyngeal bulb, *rh.* rhinophore, *s.gl.* salivary gland, *st.* stomach, *stc.* statocyst; F. post-larva with anterior tentacles and heart. c^3. cerata of the third pair.

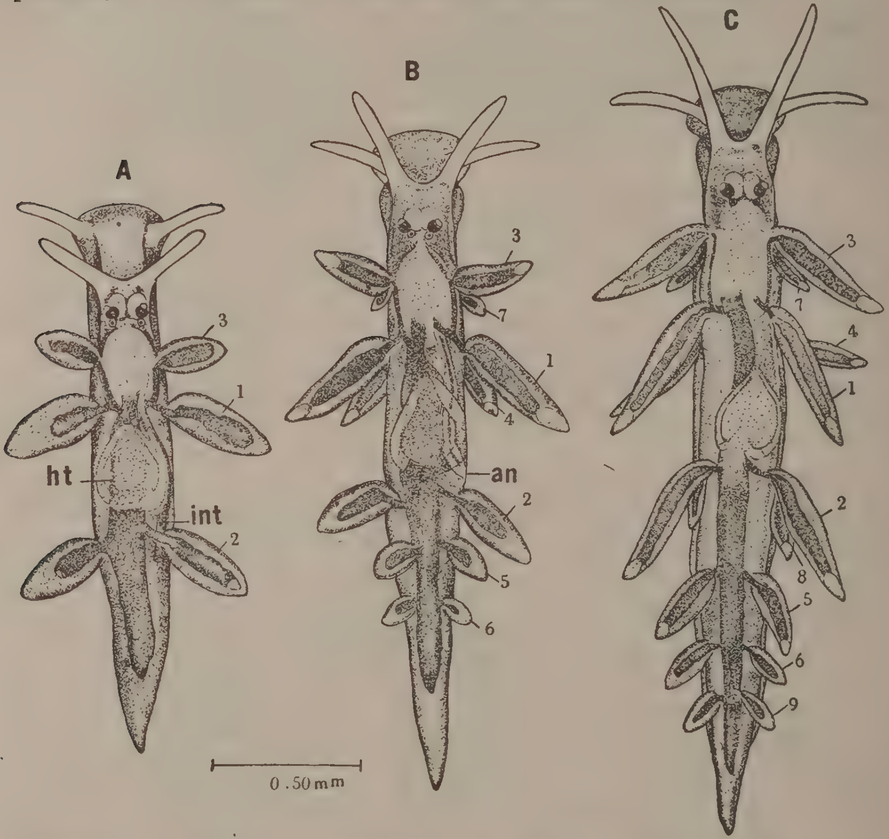
being broad. The head is prominent and the rhinophores are better developed than before, with scattered grayish pigment on their surfaces. Associated with the pharyngeal bulb is developed a pair of salivary glands, which extend from the former to a little distance hindwards on either side of the stomach. The left liver lobe instead of being an irregular mass has extended lengthwise. The cerata of the first pair have grown and a second pair of them have since appeared leaving an appreciable gap between them. The hepatic diverticula from the left liver lobe enter both the cerata of the posterior pair and of the left one only in the anterior pair, the right one of this pair having been supplied with a diverticulum of the right liver lobe. The diverticula are greenish except at the terminal regions where there are tiny clusters of clear vesicular cells. The anal opening is distinctly lateral lying beneath the right posterior cerata. The feeding activity of the form is a little greater than in the previous stage.

Post-larva with anterior tentacles and the heart.—By the end of 78 to 80 hours from the time it has dropped the shell and taken to creeping, the post-larva has grown fairly large, measuring 1430 μ long and 270μ broad (Text Fig. 3, F). It has now a pair of anterior tentacles and a distinct heart in addition to the structures described in the earlier phase. The anterior tentacles are budded off from the front region of the head. The heart which lies enclosed in the pericardium behind the region of the stomach consists of an auricle and a ventricle, the pulsations of them being visible clearly through the transparent body-wall beneath which they lie. In front of the earlier described anterior pair of cerata there has appeared another pair of them. The hepatic diverticula entering them are derived from the original liver lobes of the corresponding sides.

The juvenile stages.—Text Fig. 4, A represents a juvenile measuring 1.8 mm. in length which has resulted from the earliest creeping stage after the expiry of 120 hours. It has the same number of cerata as in the previous stage, but the formation of structures in the head and the general body contour are as in the adult. The first pair of tentacles and the rhinophores have become slender and long. The anterior region of the head is distinctly narrow and rounded in front of the first pair of tentacles. Two labial thickenings in the ventral aspect have appeared, at the sides of the mouth as in the adult. The cerebro-pleural and the pedal ganglia are well defined. The eyes reveal in each a distinct crystalline lens fitting to the pigmented retinal cup. The same juvenile has grown to 2.2 and 2.5 mm. in the next five and seven days respectively showing an increasing number of cerata which have become now grouped into clusters as represented in Text Fig. 4, B & C. The cerata are serially numbered in the order in which they have appeared during development. The well developed ones are slender, elongate, greenish gray with their tips white and provided with cnidosacs as in the adult. The anus opens laterally at the base of the third group of cerata on the right side.

CONCLUSION

The egg of *Cuthona adyarensis* is much larger and more yolky than those of most other Nudibranchs. Excluding the enclosing capsule the egg in this species measures 180 μ whereas the same is 80 μ in *Fiona marina* (Casteel, 1904), 110 to 150 μ in *Embletonia pallida* (Rasmussen, 1944), 70 μ in *Favorinus branchialis* (Rasmussen 1951) and 150 μ in *Eolidina* (*E.*) *mannarensis* (Rao & Alagarswamy, 1960). A variation in the diameter of the eggs was noticed by Rasmussen (1944) in *Embletonia pallida* from two localities, which differed in their salinity conditions, those from Isefjord (Sealand, Denmark) having higher saline waters of over 20‰ being smaller measuring 110 μ, in diameter than others ranging from 130 to 150 μ obtained from the South Harbour of Copenhagen where a low salinity of 12 ‰ prevailed. The largeness in the size of the eggs appears to be correlated with the estuarine or brackish water habitat in Adyar. Although this species has not so far been recorded, from a marine habitat the possibility of its occurrence in such an environment cannot be precluded.



TEXT FIG. 4, A. Juvenile stage five days after the larva had settled for creeping, *ht*. heart and *int*. intestine ; B & C the same juvenile after 10 and 12 days respectively, *an*. anus ; the cerata are serially numbered in the order in which they appear.

The early development of *C. adyarensis* is very rapid as is the general rule with all other invertebrate organisms from the warmer waters. At a temperature of 22°C to 24°C and in a salinity medium of 24 ‰ the veliger larvae are formed in seventy-two to eighty hours even though they are not liberated free from the capsules at least ninety-six hours after the deposition of the spawn. As compared with the present tropical species the British form, *Doris tuberculata* from the cooler waters, as remarked by Eliot (1910) has much slower rate of development, the larvae being liberated from the spawn not earlier than a fortnight after the eggs have been spawned. In *Embletonia pallida* from the South Harbour of Copenhagen the development from spawning to hatching at a temperature of 17.3°C took about nine days whereas in the same species from Isefjord this process was completed at 22°C to 25°C in four days (Rasmussen, 1944). In *Eolidina* (*E.*) *mannarensis* (Rao & Alagarswamy, 1960) the entire larval development, at 29 to 31° C and a salinity of 33.5 to 34.18 ‰, was completed in about seventy-two hours, a rate which is more rapid than that observed in *C. adyarensis*.

The briefness of the larval life in the species is a feature which it shares with all other Nudibranchs. The larvae of the Prosobranch Gastropods with comparatively larger and continuously growing shells having a greater capacity for displacement and by virtue of their possessing bigger velar lobes for vigorous propulsion in water are better fitted for a pelagic mode of existence than those of the Nudibranchs. Among the latter group the larvae with the inflated or egg-shaped type of shells are in a general way a little better suited for free swimming life than others with cup-shaped or spiral types of shells having comparatively lesser buoyancy as expressed by Thorson (1946), but this is not always true because in *Embletonia pallida* (Rasmussen, 1944) and in *C. adyarensis* described here the duration of larval life is extremely short although both these species possess the inflated type of larval shells. In both a relatively much abbreviated velum appears to be a limiting factor for a prolonged pelagic existence of the larva. It may also be stated here that the larva and the post-larval creeping stages in *C. adyarensis* are fairly robust and active and they quickly pass through their development to attain juvenile condition. The largeness of the eggs with plenty of reserve yolk, the briefness of the larval duration, the hardiness of the post-larvae and fastness in the rate of the pre-larval and post-larval development are factors conducive to successful completion of the life-history of a species living in a brackish water or an estuarine habitat where the environmental conditions being subject to very rapid changes are mostly adverse and only rarely favourable.

In regard to larval development and metamorphosis, Nordman's (1846) account of *Tergipes edwardsii* differs in some respects from Schultze's (1849) description of *T. lacinulatus* (probably synonymous with *Galvina exigua* as pointed out by Eliot, 1910). In the former species the heart was seen pulsating as early as the shelled larval stage and the anterior tentacles also appeared at the same time even before the velum was lost whereas in the latter species the heart was formed much later in the post-larva and the rhinophores appeared only after the obliteration of the velum but earlier than the formation of the anterior pair of tentacles. The sequence of these structures appearing in *C. adyarensis* is as in *T. lacinulatus*.

For the kind encouragement received from Dr. N. K. Panikkar while the work was in progress and subsequently from Dr. S. Jones when the script was under preparation the author expresses his sincerest gratitude to them.

SUMMARY

1. In an estuarine nudibranchiate mollusc, *Cuthona adyarensis* Rao of the family Tergipididae reared under laboratory conditions a complete series of developmental stages from the fertilized eggs to the juveniles has been traced.

2. The egg is fairly large, measuring about 180 μ in diameter and is enclosed in an oval, double-walled membranous capsule of about 270 μ by 200 μ. As a rule the individuals spawn only after pairing. However, juveniles isolated and reared to sexual maturity spawned without copulation.

3. After the extrusion of the polar bodies the first cleavage which has a spiral trend divides the egg into two equal halves. Subsequent cleavages are formed rapidly. Gastrulation is by invagination. The blastopore closes but the larval mouth appears subsequently in the same position. The fully formed veliger is liberated free from the spawn at the end of the fifth day.

4. The larva has an inflated or egg-shaped shell which is characteristic of the nudibranch families, Tergipididae and Flabellinidae. The soft body is plumpy and the velum is rather small. The duration of larval life is extremely short.

5. The larva begins to creep and discards its shell. Simultaneously the velum is reduced and the foot is enlarged for creeping. Jaws and radula begin to develop in the pharyngeal bulb. The earliest creeping phase has the eyes and the statocysts as in the larva. In the next twenty-four hours the post-larva develops rudiments of rhinophores and cerata.

6. In the subsequent stages the post-larvae have developed the oral tentacles and the salivary glands. The hepatic diverticula from the liver lobes show ramifications entering the cerata of which another pair has since appeared in front of the anterior pair. The heart begins to pulsate in the pericardium lying beneath the body-wall behind the region of the stomach. The anus shifts from its median position to the right side to lie close to the third pair of cerata.

7. The earliest juvenile stage is reached five days after the larva has settled for creeping. The head is narrow and rounded on front. The oral tentacles and rhinophores are slender and elongate. Eyes, the cerebro-pleural and the pedal ganglia are well developed. The cerata come to possess the cnidosacs with nematocysts. As the juveniles grow more cerata are developed.

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ON AN APPARENTLY SPECIFIC TYPE OF ABNORMALITY IN THE WHITE-SPOTTED SHOVELNOSE RAY, *RHYNCHOBATUS DJIDDENSIS* (FORSKAL)*

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INTRODUCTION

Instances of abnormalities among sharks, rays and skates are well documented in literature, but information as to the frequency of occurrence of each type of abnormality is meagre. In this connection four male and one female juvenile specimens of *Rhynchobatus djiddensis* (Forsk.) showing almost identical type of deviation from the normal ones have been examined by the author from collections made at different places along the Palk Bay recently. Similar abnormalities in other batoids have been responsible for the creation of even new genera such as *Cephaleutherus* Rafinesque, *Propterygia* Otto, and *Hieroptera* Fleming while *Cephalopterus ehrenbergii* Day (not Muller and Henle) is a misnomer for a similar abnormal form of *Gymnura* sp., as drawn attention to by Gill (1896), Gudger (1933) and Bigelow and Schroeder (1953).

Out of the several characters studied, those showing marked differences from the normal are given in Table I. All measurements taken are projected lengths and they do not follow the curvature of the body unless otherwise indicated. The body proportions (except the angle of fin corners) are recorded in thousandths of the total length. In the account dealing with the abnormality characterwise, only the instances of divergence from the normal are given.

One of the normal specimens, measuring 385 mm. in total length, examined in this connection for comparison appears to be the smallest juvenile of *R. djiddensis* on record as earlier workers (Setna and Sarangdhar, 1949) indicated the new-born to vary in length between 450 mm. and 500 mm.

MATERIAL EXAMINED

Abnormal specimens.—(1) Caught on 10-10-1960 at Devipatnam at 2 fathom depth, collected by Mr. G. Luther ; (2) Material displayed in the Central Marine Fisheries Research Institute Museum, collected by Miss Mary Samuel ; (3) and (4) Caught on 27-5-1961 and 14-6-1961 at Rameswaram at 5 fathom depth, collected by Mr. T. Ramakrishna Rao ; and (5) Caught on 24-3-1961 at Devipatnam at 2 fathom depth, collected by Mr T. E. Sivaparakasam.

In the ensuing sections, Nos. (1) to (5) indicate these abnormal specimens in the order given above.

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TABLE I

Measurements made on *Rhynchobatus djiddensis* (Forskal) recorded in thousandths of the total length

Character	Abnormal specimens					Average of Abnormal specimens	Average of 2 normal specimens.**
	1	2	3	4*	5		
Total length	374	369	385	393	352	374.6	419.5
Snout length	78	76	78	76	77	77.0	167.5
Tip of snout to :							
centre of mouth	128	136	127	132	134	131.4	213.0
anterior gill opening	201	206	190	198	205	200.0	274.0
posterior gill opening	267	271	252	260	281	266.2	321.5
umbilical opening	270	276	255	265	281	269.4	321.5
origin D1	447	436	431	445	440	439.8	477.0
origin D2	690	688	686	687	682	686.6	690.0
insertion P2	433	436	413	427	437	429.2	459.0
centre anus	457	461	442	453	460	454.6	476.0
base upper caudal lobe	856	867	865	863	861	862.4	830.5
Lth. from centre vent to tip C.	561	556	558	550	554	555.8	525.0
Wth. head at 1st gill opening	188	192	195	196	194	193.0	237.0
Greatest width body including P1	307	298	299	308	312	304.8	342.5
Dist. bet. lower margins 1st and 5th gill openings	72	68	70	66	74	70.0	56.5
Dist. bet. lower margins 5th gill opening	136	138	138	140	134	137.2	105.0
Dist. from rear base P1 to vertical from anterior fin corner to base	83	84	78	74	94	82.6	39.0
Girth body in front P2	388	407	390	377	392	390.8	343.5
Dist. bet. origins D1 and D2	251	260	260	242	250	252.6	225.5
Ht.D1 from insertion to tip anterior corner	88	92	86	76	88	86.0	138.5
Ht.D2 from insertion to tip anterior corner	78	73	75	79	80	77.0	107.5
Ht.P2 from insertion to tip anterior corner	40	43	41	46	45	43.0	81.5
Dist. from anterior corner to posterior corner P2	107	106	104	120	111	109.6	83.0
Dist. from insertion to tip posterior corner D1	134	122	132	127	125	128.0	112.5
Dist. from insertion to tip posterior corner D2	107	103	106	104	102	104.4	86.0
Dist. from insertion to tip posterior corner P2	112	106	112	125	114	113.8	127.0
Base D1	80	79	78	79	82	79.6	59.5
Angle of anterior corner P1	112°	110°	110°	109°	118°	111.8°	98.5°
Angle of anterior corner P2	90°	96°	93°	92°	91°	92.4°	104.5°

* Female.

** The two normal specimens (males) measure 385 mm. and 452 mm. in total length.

ABNORMALITY IN THE SPECIMENS STUDIED

(Fig. 1, a-d & Fig. 2 a, b)

Head.—Depressed and broadly U-shaped ; snout swollen, a shallow depression in its mid front surface with a short and blunt median projection dorsally and a broad indentation in a corresponding position ventrally ; outline of head formed by the branchial crest, angular beset with three obtuse projections, the greatest width lying across middle of orbits. Although (5) shows all these features, they are less pronounced.

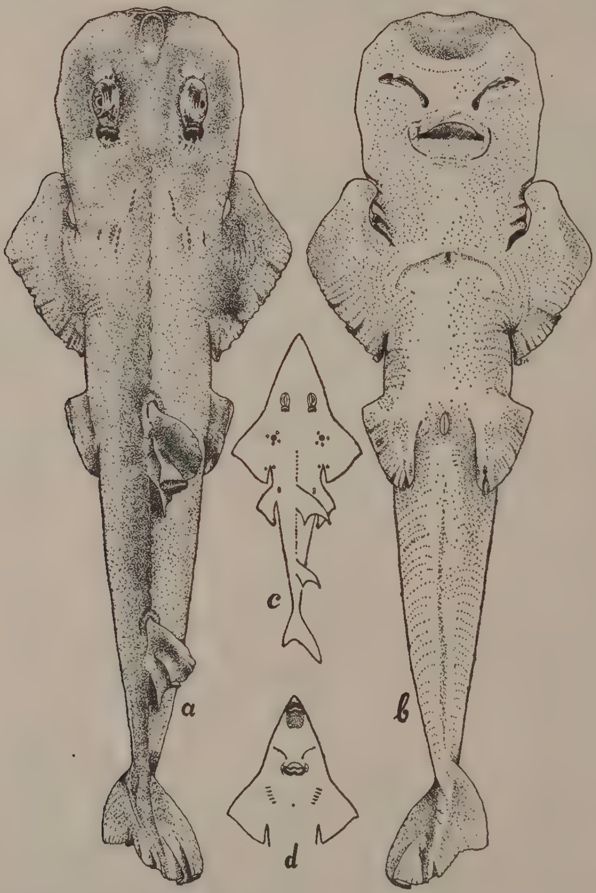

FIG. 1. *Rhynchobatus djiddensis* (Forskal). (a) dorsal view of abnormal specimen 374 mm. in total length ; (b) ventral view of same ; (c) outline drawing (diagrammatic) of dorsal view of a normal specimen ; (d) ventral view of head and anterior part of same.

Branchial openings.—A row of five on either side of body progressively increasing in width (exception (5) in which fifth pair narrow) but completely hidden when viewed dorsally although first four pairs in (1), (2), (3) & (4) and three pairs in (5) are ventrolateral in position.

Pectoral fins.—Lobate antero-posteriorly and inserted at side of body by moderate base bordering and behind fourth gill opening in (5) and fifth gill opening in (1), (2), (3) and (4) ; anterior lobe moderately thick and short with a knob-like tip and curved inwards extending to space between first and second gill openings ; and presenting a more elongated appearance when viewed ventrally ; outer margin of fin behind the anterior fin corner wavy and upturned. The ' epidermal bud ' referred to later is not seen in the angle formed by the anterior lobe of pectoral with the body.

Pelvic fin.—Anterior straight margin much shorter than convex posterior margin ; posterior tip of fin less produced but acute ; outer margin of fin behind the anterior fin corner wavy and upturned.

First and second dorsal fins.—A deep fold in each arising from middle of base ; fins relatively reduced in height ; first dorsal much more so. The anterior fin corner rounded ; distal margin of fin irregular and wavy.

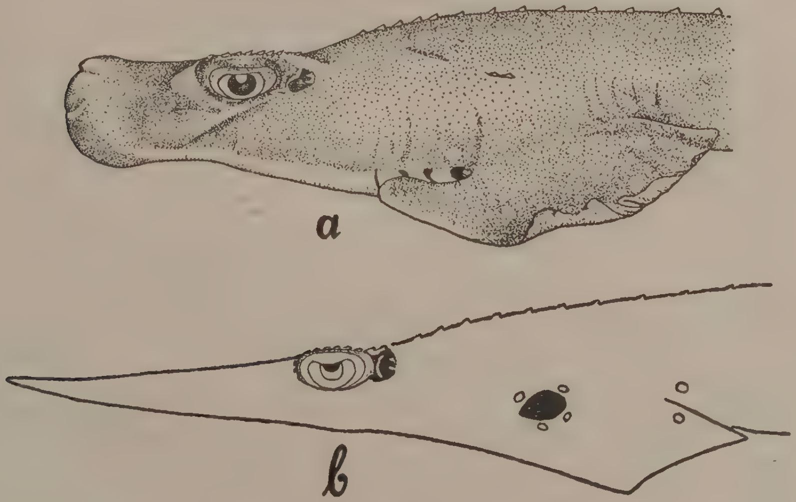

FIG. 2. *Rhynchobatus djiddensis* (Forskal). (a) lateral view of abnormal specimen 374 mm. in total length showing the almost truncate snout, cleft pectoral and partly laterally placed gill openings ; (b) lateral view of head and rostrum of normal specimen 385 mm. in total length showing the acute snout and the disposition of the normal pectoral.

Caudal fin.—Inconspicuously bilobed due to partial non-development of upper and lower lobes ; a deep fold of the type as seen in dorsals distally present along middle of upper lobe of fin ; distal margin of fin irregular and wavy.

Colour.—On preservation in formalin dorsum light greyish to pale yellow, ventral side dirty white ; dusky patch on supra-orbital membrane on each side present as in normal specimens ; ventrally, an anterior broad semicircular dusky patch on snout with a narrow transverse white band close to front border present in (1) and (2) ; only the white band not present in (3) and the dusky patch being absent in (4) & (5) ; in normal specimens it is elongated with a relatively narrow and less wider white band ; a pair of black lateral spots present on margin of snout anterior to dusky patch in normal specimens not discernible in these five specimens. The white spots present on dorsum of (1), (2) and (3) as in the smaller normal juvenile and more in number in (4) & (5). The black shoulder spot with a few white spots around, absent in (1) but present in (2), (3), (4) and (5) ; an additional shoulder spot present in (2) on the left very near to the mid dorsal line.

Teeth, scales, tubercles and the lateral keel present as in normal.

Discussion

Setna and Sarangdhar (1948) described a shark-like stage in the embryonic development of *R. djiddensis* at 45 mm. length. This corresponds to the 10th stage described by Melouk (1949) in the same species at 42 mm. length. The embryo at this stage has the head swollen and soft with two stud-like eyes laterally and a downwardly projected short blunt triangular soft snout ; a branchial crest, on either side, above the lateral row of gill slits with the external branchial filaments and forming a ' rostral anlage ' at the mid line of the forehead ; anterior base of pectoral behind 5th gill opening with the anterior and posterior lobes free from body ; all fins developed in their respective adult positions—dorsals nearly semi-circular, caudal lunate and pelvics reniform in their shapes. The appearance of the adult shape is reported at 95 mm. length. During the course of its further development the branchial filaments are absorbed, body pigmentation, scales and tubercles are developed and the foetus is reported to be more or less a perfect replica of the parent at 437 mm. length except for the presence of the yolk-sac.

The specimens under discussion bear a close morphological resemblance to the developmental stage at 42-45 mm. length mainly in the shape and position of the pectorals, exception being (5) which resembles the 11th stage at 50 mm. length (Melouk, 1949) only in the extent of fusion of the pectoral to the branchial crest, the shape of rostral development and the general shapes of the dorsals and pelvic. They, however, differ from this stage, apart from the size, in the absence of the swollen head and the external branchial filaments, the shifting of the eyes to the normal dorsal position, the possession of the bilobed caudal fin, body pigmentation, scales and tubercles. The shortness and folds of the dorsal and caudal deserve special mention. It could be seen that while certain structures kept pace with the course of development, certain other structures have considerably lagged behind. This irregularity in the succession of appearance of the various characters are probably due to the irregularities in the activity of the corresponding factors of growth during development. The failure of the ' rostral anlage ' to grow further and the non-development of the ' epidermal bud ' which is said to represent a point of growth regulating the fusion of the pectoral to the branchial crest (Melouk, 1949) may be held responsible for the non-formation of the ' rostrum ' and the ' disc ' respectively. The shortness and folds of the dorsals and caudal are probably due to differential growth in the different axes. De Beer (1958) states that ' the strengths of the internal factors of development can vary and exert their effects at different rates, with the result that the time of appearance of a structure can be altered. To this shifting in the appearance of the character in the time scale, the term ' heterochrony ' is applied.'

But the specimens discussed here do not appear to come under any of the eight categories of heterochrony given by De Beer (1958) and in all probability they represent a teratological condition.

When one has occasion to examine such teratological embryos *in situ* it will be worthwhile noting the number of embryos in each uterus, their sex-ratio and the incidence of sexwise abnormalities, if any, of the type described here and the occurrence or otherwise of such freaks due to over-crowding of embryos present in a litter. The commonest number of young ones produced is eight, being four from each uterus (Setna and Sarangdhar, 1949). The author has observed on several occasions the snout development to vary widely, from bluntly round to the normal acute condition in young ones of *R. djiddensis*, which could be considered otherwise normal. Strangely enough, the abnormal specimens under discussion are of about the same size. It would be interesting to know if these freaks would survive and attain adulthood.

ACKNOWLEDGEMENT

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J. Mar. biol. Ass. India, 1961, 3 (1 & 2): 204-208

THE PEARL FISH *CARAPUS MARGARITIFERAE* (RENDAHL), A NEW RECORD FOR THE INDIAN WATERS*

By S. Mahadevan

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In a recent communication (Mahadevan 1959) attention was drawn to an interesting association of the pearl fish *Fierasfer homei* (Richardson) with the wing mussel *Pteria* sp.,** found in the Gulf of Mannar off Tuticorin. A re-examination of the pearl fish showed that the position of the vent is at the base of a line just behind pectoral origin and the origin of the dorsal is in a line above the middle of pectoral (Plate, 1, Fig. C). Further, other distinguishing characters of this fish described elsewhere in this account justified the earlier doubts (Mahadevan *op. cit.*) of the likelihood of its coming under *Carapus* (syn : *Fierasfer*) *margaritiferae* (Rendahl), a brief account of which is given by de Beaufort (1951) based on specimens collected from Pulu Punga, Pulu Missa, coast of Flores and Cape Jaubert N. W. Australia, mostly in association with the wing mussel or sometimes with a holothurian. Smith (1955), while reviewing the family Carapidae has mentioned the occurrence of *C. margaritiferae* in South African waters also where three specimens, 75-93 mm. in length, were 'taken from inside clams at Durban.' The data on two specimens of 63.5 and 85.0 mm. examined by the present author indicate differences in some of the characteristics as compared with the South African form described by Smith. In order to facilitate comparison of the Indian form with others occurring elsewhere a detailed description of the material in hand is given below.

Description

Head and body compressed from side to side ; dorsal profile rises to just behind occiput from whence it gradually slopes to end of tail ; ventral profile conspicuously concave from below gill opening to vertically below 22nd dorsal ray from whence it gradually rises to caudal tip ; sides of the body show from behind head to tail V-shaped myotomes pointed anteriorly ; abdominal wall translucent, showing the disposition of the alimentary canal and the air-bladder ; eye without free orbital margin ; interorbital space convex ; mouth oblique ; maxillary with free margin reaching far behind hind border of eye ; jaws subequal ; a pair of recurved caniniform teeth on each side of symphysis of upper and lower jaw ; maxillary and mandibular teeth bluntly conical with tips worn out, especially in the larger teeth ; vomer knob-like projecting into the oral cavity and with a number of blunt conical teeth (Fig. 1, A) ; those in the centre being relatively large ; similar rows of smaller teeth present in the palatine ; pectoral well developed with 16 rays on either side ; dorsal originates in a line behind anal but above pectoral middle ; anal fin deeper than height of dorsal, former with 171 and latter with 162 rays ; vent distinctly behind pectoral origin (Plate 1, Fig. D) ; vertebrae 89, of which anterior 8 appear to represent precaudal vertebrae ; (a check of the latter could not be made as the alizarin stained material is not available now) first dorsal ray appears opposite the fifth vertebra ; lower limb of outer arch of gill carries three elongate gill-rakers of almost same length, being more than twice length of longest gill filament.

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** Vide Rao, K. V. on page 259 of this journal.

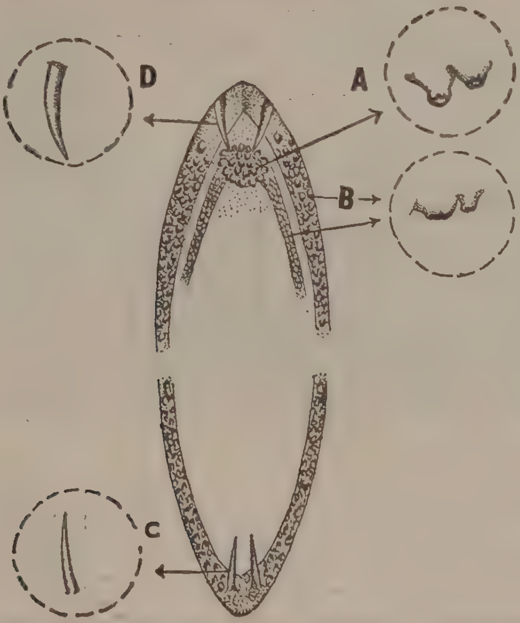

FIG. 1. Diagram showing the dentition of *C. margaritiferae*. A. Vomerine teeth. B. Maxillary and Palatine teeth. C. Caniniform teeth in lower jaw. D. Caniniform teeth in upper jaw.

Table 1, gives details of body proportions and to facilitate comparison the available data on the South African form as given by Smith (1955) is also included.

REMARKS

From the foregoing account and the table 1 it would appear that the percentage of measurement of the different characters studied are uniformly greater for the Indian form than those from South Africa, although the specimens are more or less of the same size. Smith (1955) mentions the pectoral fin ray count as ' about 15.' There being no data regarding the dorsal and anal fin ray count for his specimens it is not possible to attempt any detailed comparison. Since we are likely to find differences in the body proportions in this fish as growth advances it is hoped that the data presented here will be useful to ascertain the extent of variations in such characteristics as and when material becomes available.

TABLE 1

Characters observed	Locality				
	Gulf of Mannar				Durban (S. Africa)
	Specimen A		Specimen B		
	mm.	%	mm.	%	%
Total length	85	100	63.5	100	100
Length of head	—	—	8.6	13.4	12.0
Width of head	—	—	3.7	5.83	4.3
Snout	—	—	1.9	2.99	2.1
Diameter of eye	2.0	2.3	1.7	2.68	2.2
Interorbital	—	—	1.8	2.83	1.6
Length of maxilla (snout to the angle of the mouth)	—	—	5.3	8.35	7.5
Depth of the body at anal	10.0	11.7	7.5	11.81	10.0
Width of the body at the pectoral origin	—	—	3.2	5.04	3.2
Width of the body at the anterior part of the tail	—	—	2.0	3.14	—
Length of the pectoral	—	—	4.4	6.93	6.50
Predorsal	—	—	11.4	17.95	17.0
Prepectoral	—	—	8.6	13.50	11.50
Preanal	—	—	9.3	14.65	13.0
Greatest height of dorsal	—	—	0.7	1.10	1.40
Greatest height of anal	—	—	1.7	2.68	3.0

(de Beaufort (1951) gives the measurements as Height 9.4—11.6 in total length. Breadth 2.2—2.4 in height. Head 7.6—9 : Eye 3.6—4.4. Length of one fish 92 mm.)

The distribution, at present, of *C. margaritiferae* suggests the possibility of other species of the same genus also occurring in the Indian waters. Smith (1955) recognised 8 species from the Western Indian Ocean viz : *C. margaritiferae* (Rendahl), *C. parvipinnis* (Kaup), *C. neglectus* (Peters), *C. homei* (Richardson), *C. reedi*, *C. pindae*, *C. cinereus* and *C. mayottae*, the last four having been recorded by him as new to science. Of the accounts of *Fierasfer homei* (=*C. homei*) given by Day (1889), Mukerji (1932) and Munro (1955) from the Indo-Ceylon waters, the form described by Mukerji (Plate 1, Fig. B) appears to be more akin to the typical *C. homei*. Day's figure of *C. homei* shows the origin of the anal to be distinctly behind the base of the pectoral. However, the dorsal has been shown as originating in a line behind the tip of pectoral which condition is typical of *C. homei*. It is felt that a re-examination of Day's material is necessary.

Species of *Carapus* are known to be in association with echinoderms and molluscs and it is interesting to note that *C. margaritiferae* has been collected from a bivalve of the genus *Pteria* from the East-Indies as well as from the Gulf of Mannar. It may be mentioned here that during the pearl fishery off Tuticorin in 1957 Mr. Dumas, a French diver collected five specimens of the bivalve *Pteria* of which four specimens contained one each of the presently described *C. margaritiferae*. More recently Dr. Bascheri Salvadori, F.A.O. diving expert informed me that during the 1958-59

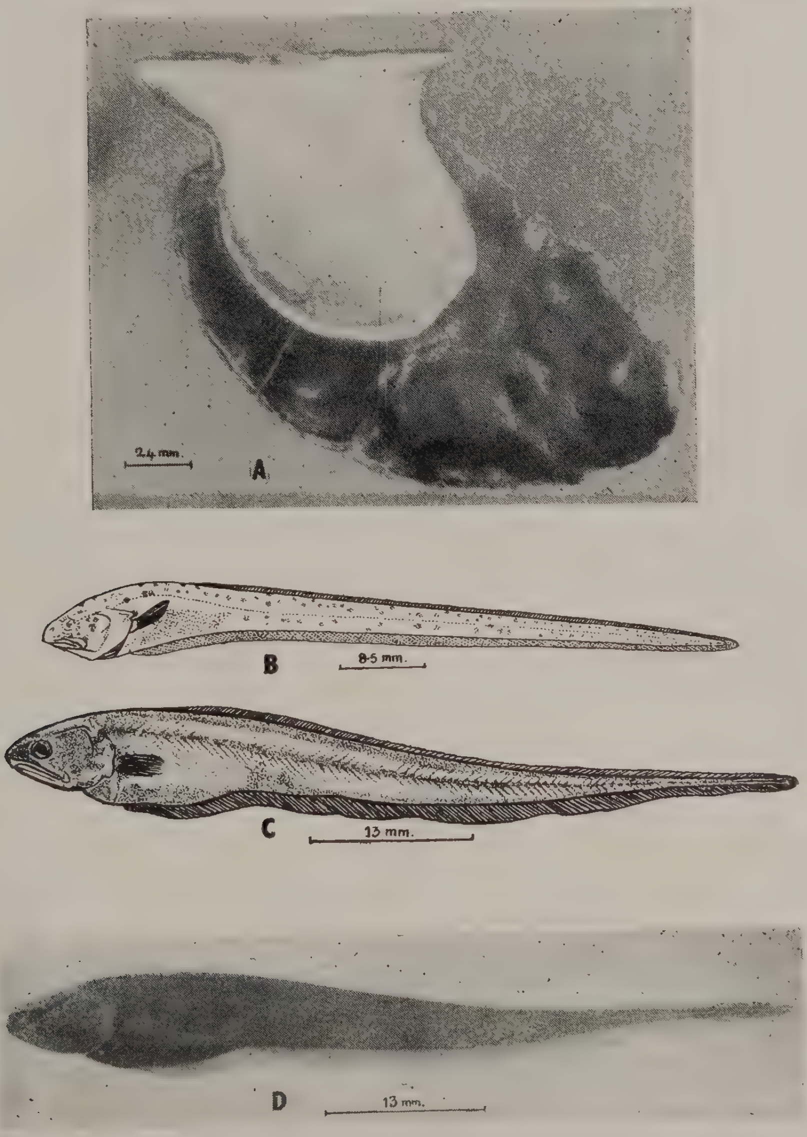

Plate I A. Photograph of *Pteria sp*. B. *Carapus homei* Rich. (figure after Mukerji). C. *Carapus margaritiferae* (Rendahl). D. *Carapus margaritiferae* (Rendahl)—photograph.

pearl fishing he had collected five specimens of the same bivalve from the same locality, of which three contained one specimen each of *C. margaritiferae*.

The shell of the wing mussel is reproduced here in Plate 1, Fig. A to enable other workers to identify the form and obtain the pearl fish harboured in them.

ACKNOWLEDGEMENT

The author's thanks are due to Dr. S. Jones for the interest shown in the preparation of this account and to Dr. E. G. Silas and to Sri. K. V. Rao for the great pains they have taken in going through the manuscript and offering criticism and suggestions. He is also grateful to Sri P. R. S. Tampi for taking the two photographs.

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ON SOME NEW RECORDS OF PIGFACE BREAMS (FAMILY LETHRINIDAE : PISCES) FROM THE ANDAMAN SEA*

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INTRODUCTION

In the course of two tours to the Andaman-Nicobar Islands by members of this Institute during February-March 1960, and January-March 1961, some specimens of lethrinid fishes, popularly known as pigface breams were obtained, all taken on hook and line in the vicinity of Port Blair and Neil Island, Andamans. Day (1870) recorded two species, *Lethrinus xanthotaenia* Bleeker, and *L. harak* (Forskal) from Andamans, while Herre (1941) listed *Lethrinus ornatus* Cuvier and Velenciennes, and *L. rhodopterus* Bleeker from the Andaman Sea. Of these, *L. xanthotaenia* is a synonym of *L. ornatus* (Weber and de Beaufort, 1936, p. 447) and we consider *L. rhodopterus* a synonym of *L. harak* (p. 4), thus leaving only two species *L. ornatus* and *L. harak* known from the Andaman waters up to now. Besides material of these two species, the present collection also includes three additional records of lethrinid fishes from the Andaman Sea, and of these, one is reported here for the first time from Indian waters.

The differentiation of the species in Lethrinidae is made difficult on account of the uniformity in meristic counts throughout the group. Primary importance is given to variations in body proportions and colouration, but the former is subject to considerable variations with age, while except for the basic colour, other colour patterns fade rapidly after death so much so formalin preserved specimens show more or less uniform colouration.

Besides Day's (1875) account of eight species of Lethrinidae from Indian Seas, the nomenclature and status of some of which require clarification, we find the regional works on this group carried out by Weber and de Beaufort (1936) for the Indo-Australian Archipelago, and Smith (1959) for the Western Indian Ocean as very useful aids to the study of these fishes from the Indian Seas. We are in agreement with Smith (1959) in his recognition of *Lethrinella* Fowler as a distinct genus to include certain species placed by earlier workers under *Lethrinus* Cuvier. The two genera are mainly separated on the nature of the dentition, the maxillary and mandibular teeth behind the canines being conical in both young and adults of *Lethrinella*, while the posterior maxillary and mandibular teeth are molariform in *Lethrinus*. In addition, species of *Lethrinella* have comparatively more elongate snout and less deeper body. As our material indicate, both these genera are represented in Andaman waters.

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Since there appears to be some differences in the methods used for taking morphometric measurements in lethrinids, for such of those characters which require clarification we give below the methods used in this study. The standard length is measured from the tip of the upper lip with the mouth closed, to the posterior margin of the last scale of the lateral line. The preorbital depth is the distance from the anterior end of the lower limb of the preoperculum to the profile of head above the posterior nostril. The length of the caudal peduncle is measured from the posterior end of base of anal to the margin of the last lateral line scale. The scales above the lateral line are counted in an oblique series below the sixth dorsal spine to lateral line excluding the latter. Generally the first scale is reduced. The scales below the lateral line are counted in the same oblique series backwards to the base of the anal. The methods used for the other characters are self explanatory. Brief diagnosis of each species is given below, and detailed data is tabulated at the end. A separate list of references is not given at the end, as those referred to are given under the species.

NOTES ON THE SPECIES

Genus **LETHRINELIA** Fowler

Lethrinella microdon (Valenciennes)

Lethrinus microdon Valenciennes, 1830. *Hist. Nat. Poiss.*, **6** : 295 (Type locality : Buru, East Indies) ; Weber and de Beaufort, 1936. *Fish. Indo-Austral. Archipel.*, **7** : 436-37, fig. 87.

Lethrinus rostratus Day, 1875. *Fish. India*, 134, pl. 33, fig. 1 (*nec* Valenciennes).

Lethrinella microdon Smith, 1959. *Ichth. Bull. No.* 17, *Dept. Ichth. Rhodes Univ. Grahamstown*, 293, pl. 25, fig. 9073.

1 specimen : 236 mm. Port Blair—March 1960.

3 specimens : 182, 207, and 227 mm. Port Blair—March 1961.

D. X, 9 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. l. 47-48 ; L. tr. 5/1/14-15. Scales round caudal peduncle 23-24. Gill rakers 4-5+5-6.

Height of body 3.1-3.3 and head 2.6-3.0 in standard length. Eye 3.9-4.51 in head, 1.9-2.2 in snout, 1.8-2.0 in preorbital depth, and 0.9-1.16 in interorbital distance. Pectoral 1.34-1.45, pelvic 1.53-1.64, base of soft anal 2.4-2.8, and longest anal ray 3.0-3.46 in head length.

Two or three radiating stripes from front of eye to snout are very characteristic of this species.

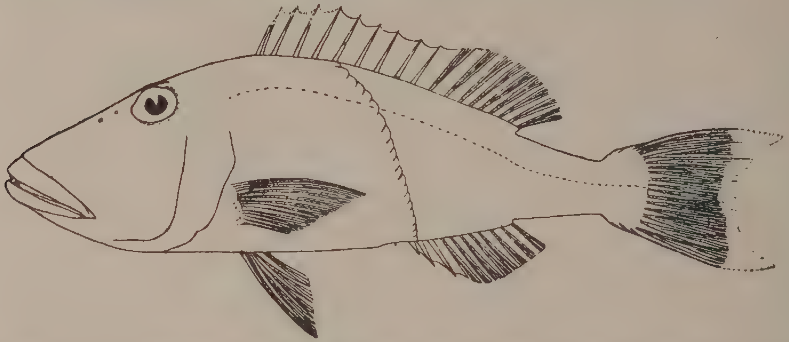
New distributional record for the Andaman Sea.

General Distribution : Red Sea, Zanzibar; Coast of India and Ceylon; Andaman Sea ; and Indonesia to Philippines.

Lethrinella xanthocheilus (Klunzinger)

(Text-fig. 1 and Plate I, Fig. 1)

Lethrinus xanthochilus Klunzinger, 1870. *Synopsis Fische Rothen Meeres*. 753 ; 1884. *Fische Rothen Meeres*. 39, pl. 6, fig. 3, (Type locality : Red Sea).



TEXT-FIG. 1. *Lethrinella xanthocheilus* (Klunzinger) 593 mm. in standard length. (A row of transverse scales on the body is also shown).

Lethrinella xanthocheilus Smith, 1959. *Ichth. Bull. No*. 17, *Rhodes Univ. Grahamstown*, 292, pl. 22, Fig. B.

1 specimen : 593 mm. Port Blair—March 1961.

D. X, 9 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. 1.50 ; L. tr. 5/1/15. Scales round caudal peduncle 24. Gill rakers 5+5.

Height of body 4.03 and head 3.38 in standard length. Eye 4.93 in head, 2.93 in snout, 2.93 in preorbital depth, and 1.21 in interorbital distance. Pectoral 1.63, pelvic 1.92, soft anal base 2.91, and longest anal ray 3.62 in head length.

This species is characterised by the interorbital space being very flat, the supraorbital margin being in line with the dorsal profile of the head, and the posterior nostril being almost midway between the tip of the snout and the hind end of the head in the adult. In life, a conspicuous red spot is present on the upper side of the base of the pectoral fin.

L. xanthocheilus has hitherto been reported only from the Red Sea, and the South African coast and adjacent islands of the Western Indian Ocean and as such this constitutes a new faunal record for the Eastern Indian Ocean as well as Indian Seas.

Lethrinella prox. **xanthocheilus** (Klunzinger)

(Plate I, Figs. 2 and 3)

1 specimen : 224 mm. Neil Island—March 1960.

1 specimen : 160 mm. Port Blair—March 1961.

D. X, 9 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. 1. 48-49 ; L. tr. 5/1/14-15. Scales round caudal peduncle 23-24. Gill rakers 4+5.

Height of body 3.11-3.26, and head 2.6-2.8 in standard length. Eye 3.5-3.61 in head, 1.58-1.83 in snout, 1.79-1.94 in preorbital depth, and 0.94-1.12 in interorbital distance. Pectoral 1.32-1.54, pelvic 1.54-1.8, base of anal 2.71-2.74, and longest anal ray 3.4-3.87 in head length.

The body proportions given above as well as those given in the table at the end indicate notable differences between these two specimens and the specimen of *L. xanthocheilus.* However, the flattened interorbital space and the supraorbital margin being in line with the dorsal profile indicate strong affinities of the two specimens to *L. xanthocheilus*, although in one notable feature of colouration, namely in the position of the reddish axillary spot in life at the pectoral base there is difference. As already mentioned, in *L. xanthocheilus* this spot is a very conspicuous feature at the upper half of the outer side of the base of the pectoral fin, while in these two specimens they occupy a position (as indicated by the yellowish spot, originally reddish above the pectoral base covering a few scales, showing no trace of such colour on the base of the pectoral. It is not possible at present to say whether this condition is characteristic of juveniles of *L. xanthocheilus.* Again, as in an allied species, *Lethrinella variegatus* (Valenciennes) the hind nostril in these specimens is distinctly nearer the tip of the snout than to the hind end of the head, but from Smith's Key to the Western Indian Ocean species of *Lethrinella* it would appear that juveniles of *L. xanthocheilus* also show a condition where the posterior nostril is slightly nearer the tip of the snout. The superior position of the eye, the flattened interorbital space and the absence of any radiating stripes in front of the eye on the snout distinguish these specimens from *L. microdon.* Besides, when compared with specimens of *L. microdon* of similar size, these specimens show more strongly developed canines. From *Lethrinella miniatus* (Forster-Schneider), another widely distributed species, these differ in having only 5 instead of 6 scales above the lateral line, the absence of radiating streaks in front of the eye and the relatively shorter snout. The distinctly convex interorbital and the eye being slightly below the dorsal profile distinguishes *Lethrinella conchyliatus* Smith, a species described recently from North Mozambique and Kenya from these two specimens. The balance of probability is that these may be juveniles of *L. xanthocheilus*, but in view of our inadequate knowledge about the range of differences to be expected in juveniles and adults of this species, we consider it desirable to treat these as *Lethrinella* prox. *xanthocheilus* until a good series of specimens is available for more detailed comparison.

Genus **LETHRINUS** Cuvier

Lethrinus harak (Forskal)

Sciaena harak Forskal, 1775. *Descrip. Animalium.* 52 (Type locality : Red Sea).

Lethrinus harak Bleeker, 1850. *Verh. Bat. Gen.*, 23 : 15 (1849) ; Day, 1870. *Proc. Zool. Soc. London*, 684 (Andamans) : 1875. *Fish. India*, 137, pl. 33, fig. 3, Fourmanoir ; 1957. *Mem. Inst. Sci. Madagascar*, 1 (ser. F.) : 126.

Lethrinus rhodopterus Bleeker, 1852. *Nat. Tijdschr. Ned. India*, 3 : 651, (1851) ; Weber and de Beaufort, 1936. *Fish. Indo-Austral. Archipel.*, 7 : 450-451 ; Herre, 1941. *Mem. Indian Mus.*, 13 : 365 (Andamans).

1 specimen : 257 mm. Port Blair—March 1961.

D. X, 9 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. 1. 47 ; L. tr. 6/1/14½. Scales round caudal peduncle 25. Gill rakers 5+5.

Height of body 2.82, and head 3.29 in standard length. Eye 3.7 in head, 1.85 in snout, 2.23 in preorbital depth, and 1.09 in interorbital distance. Pectoral 0.97, pelvic 1.21, base of soft anal 2.22, and longest anal ray 2.88 in head length.

Very characteristic of this species is the black lateral blotch between 15th and 22nd scales of lateral line and from the lateral line row extending downwards for two or three scale rows.

Forskal (1775) described *Sciaena harak* (=*Lethrinus harak*) from the Red Sea, and Klunzinger (1884) reported it as having 4½ scales above the lateral line. Bleeker (1850)) recorded *L. harak* from Java Seas, but later (1852) redesignated this as a new species—*L. rhodopterus* since the specimens showed six rows of scales above the lateral line instead of 4½. Unaware of this, Klunzinger (1884) named Bleeker's *L. harak* (*nec* Forskal) from Java Seas as *Lethrinus bleekeri*, but as pointed out by Weber and de Beaufort (1936) *L. bleekeri* Klunzinger becomes a synonym of *L. rhodopterus*. Several authors have followed Weber and de Beaufort (op. cit.) in recognising *L. harak* (Forskal) as distinct from *L. rhodopterus* Bleeker. Our specimen shows 6 scales above the lateral line (half scale at the base of the sixth dorsal spine counted as one) in which it agrees with descriptions of specimens from Indonesian waters (*L. rhodopterus* Bleeker : Weber and de Beaufort, 1936) ; from Madagascar (*L. harak* (Forskal) : Fourmanoir, 1957) ; and from Western Indian Ocean (*L. harak* (Forskal) : Smith 1959). Further, Smith (1959) has shown that Ruppell's figure of *L. harak* (Forskal) has six scales above the lateral line and not 4½ as mentioned by Klunzinger (*op. cit.*). Besides, the dark lateral blotch below the lateral line, so characteristic of this species, occurs also in *L. rhodopterus* Bleeker and the body proportions and the general colouration of the two are also in agreement. Hence it is likely that only one species—*L. harak* Forskal is distributed from Red Sea eastwards to the Philippines, Queensland, Samoa, and Tonga. For other synonyms of *L. harak*, reference may be made to Weber and de Beaufort (1936) under *L. rhodopterus*.

General Distribution : From Red Sea along East African Coast to Natal and to Riu-Kiu Islands in North Pacific and Samoa and Tonga Islands in the South Pacific.

Lethrinus ornatus Valenciennes

Lethrinus ornatus Valenciennes, 1830. *Hist. Nat. Poiss.*, 6 : 310 (Type locality : Java). Herre, 1941. *Mem. Indian Mus.*, 13 : 365 (Andamans).

1 specimen : 187 mm. Port Blair—February 1960.
1 specimen : 192 mm. Port Blair—March 1961.

D. X, 9-10 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. 1. 47-48 ; L. tr. 5/1/13-15. Scales round caudal peduncle 22-24. Gill rakers 5-6+5.

Height of body 2.98-3.14, and head 3.01-3.04 in standard length. Eye 3.0-3.75 in head, 1.54-1.59 in snout, 1.85-1.89 in preorbital depth, and 0.94-0.95 in interorbital distance. Pectoral 0.97-1.08, pelvic 1.21-1.32, base of soft anal 2.25-2.7, and longest anal ray 2.43-2.57 in head length.

Four light yellowish (light reddish in life) longitudinal bands from hind end of head to caudal peduncle are present, of which the second from the top situated just below the lateral line is the most conspicuous. The interspaces between the bands are light dusky, and the head is mostly dusky except a few lighter patches. A few dark spots are present on the sheath of scales at the base of the soft dorsal. The opercular edge is tinged yellow (orange coloured in life).

General Distribution : Ceylon, Gulf of Mannar ; Andaman Sea ; Indonesia to Philippines and Formosa in the north, Queensland and Tonga in the south.

Lethrinus nebulosus (Forskal)

Sciaena nebulosus Forskal, 1775. *Descrip. Animalium*, 52 (Type locality : Red Sea).

Lethrinus karwa Day, 1875. *Fish. India*, 134, pl. 33, Fig. 2.

Lethrinus nebulosus Day, 1875. *Ibid.*, pl. 33, Fig. 4.

Lethrinus nebulosus Weber and de Beaufort, 1936. *Fish. Indo-Austr. Archipel.* **7** : 453-455, Fig. 84.

1 specimen : 350 mm. Neil Island—March 1960.

3 specimens : 147, 181, and 185 mm. Port Blair—March 1961.

D. X, 9 ; P_1. ii, 11 ; P_2. I, 5 ; A. III, 8 ; C. i, 15, i ; L. 1.47-48 ; L. tr. 6/1/14-15. Scales round caudal peduncle 24-25. Gill rakers 4-5+5.

Height of body 2.57-2.78, and head 2.82-3.08 in standard length. Eye 3.70-4.14 in head, 1.70-2.42 in snout, 1.77-2.64 in preorbital depth, and 0.96-1.2 in interorbital distance. Pectoral 1.03-1.16, pelvic 1.33-1.61, base of soft anal 2.4-2.63, and longest anal ray 2.85-2.94 in head length.

New distributional record for Andaman waters.

General Distribution : From Red Sea and East African Coast to the Chinese Coast as well as to Fiji Islands in the South Pacific.

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TABLE I

(Body proportions in thousandths of standard length)

Genus	*Lethrinella*						*Lethrinus*						
Species	*microdon*			*xanthocheilus*	prox. *xanthocheilus*		*ornatus*		*harak*	*nebulosus*			
Standard length (mm.)	236	227	207	182	224	160	192	187	257	350	185	181	147
Head length	335	341	372	346	379	356	328	332	304	331	324	354	340
Snout length	169	167	188	170	192	169	169	158	152	194	162	171	156
Eye diameter	74	77	89	88	105	106	109	99	82	80	86	88	92
Interorbital distance	87	79	104	80	118	100	104	94	89	97	84	86	85
Snout to Post-nostril	148	152	169	148	183	156	141	139	136	163	135	138	139
Post-nostril to hind margin of head	201	207	222	220	232	225	227	230	212	183	216	227	235
Preorbital depth	148	152	164	159	188	175	203	187	183	211	178	166	163
Depth at angle of pre-opercle through middle of eye	203	185	198	187	228	216	260	141	214	256	232	221	218
Length of maxilla	121	128	130	126	150	150	133	136	130	163	135	135	133
Snout to origin of D	390	383	415	407	429	413	427	412	397	440	405	409	415
Snout to P_2	377	388	420	387	429	406	375	385	370	409	389	420	415
Snout to A	640	630	671	621	670	650	625	658	650	669	649	669	660
P_2 to anal origin	271	269	256	266	254	256	266	286	292	274	281	265	282
Longest dorsal spine	114	117	135	115	114	131	125	136	125	104	138	138	136
Longest dorsal ray	119	123	123	121	116	113	141	144	125	131	146	141	136
Length of P_1	233	251	256	258	246	269	339	305	311	311	314	309	293
Length of P_2	203	222	227	214	210	231	271	251	249	249	232	232	211
Soft anal base	136	139	135	121	138	131	141	123	136	126	135	141	129
Longest anal ray	95	101	111	115	98	103	128	136	105	111	114	124	116
Length of caudal peduncle	201	218	222	242	212	206	219	225	226	214	224	229	224
Least ht. C. peduncle	95	90	92	93	92	94	120	118	121	106	111	116	109
P_1 insertion to origin of dorsal	220	198	198	209	219	200	255	254	243	271	254	260	245
Greatest depth of body	322	304	275	297	321	306	375	353	354	389	368	359	361
Height at anal origin	284	264	261	291	272	281	318	321	315	329	319	307	313

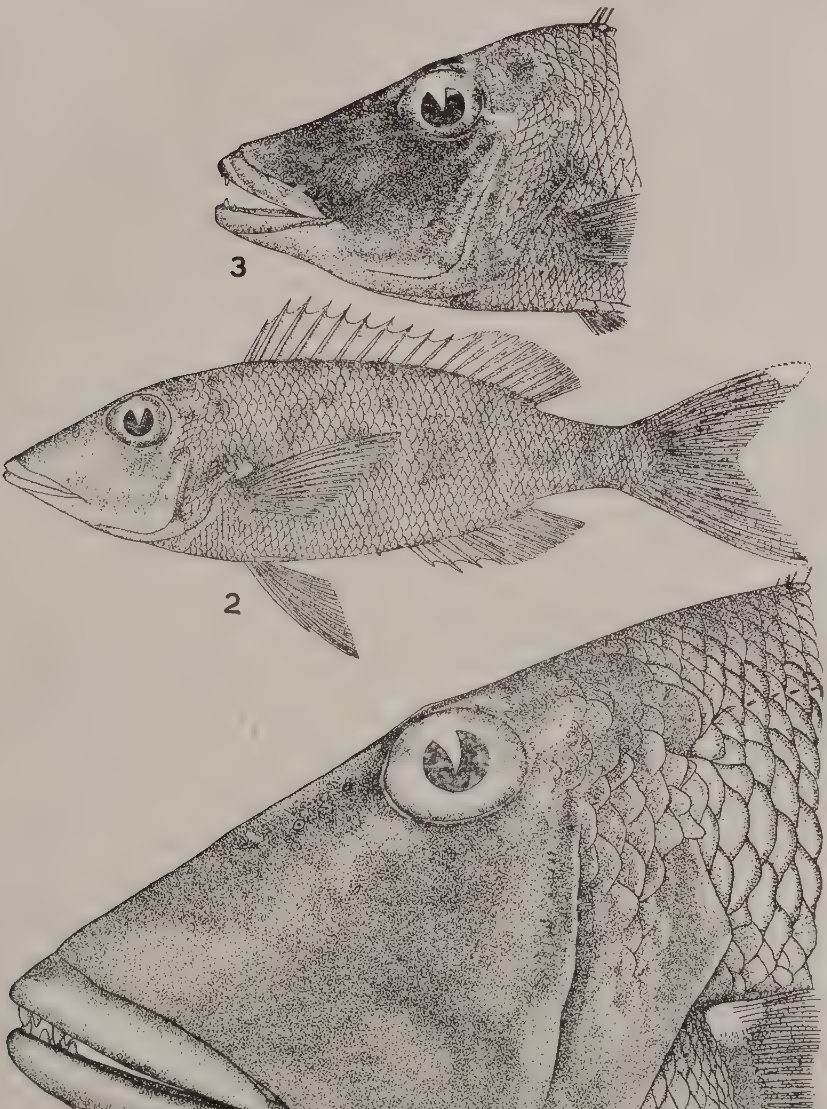

FIG. 1. *Lethrinella xanthocheilus* (Klunzinger). Head of 593 mm. specimen. Note position of eye and lighter spot at base of pectoral.

FIGS. 2 and 3. *Lethrinella* prox. *xanthocheilus* (Klunzinger). (2) Lateral view of 160 mm. specimen ; (3) Head of 224 mm. specimen.

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COMPARATIVE OSTEOLOGY OF THE RIBBON FISHES OF THE FAMILY TRICHIURIDAE FROM INDIAN WATERS, WITH REMARKS ON THEIR PHYLOGENY*

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INTRODUCTION

The ribbon fishes of the family Trichiuridae are represented by three genera and four species in Indian waters (James 1959) and are the subject of one of the important commercial fisheries. The genus *Eupleurogrammus* Gill is represented by two species namely *E. intermedius* (Gray) and *E. muticus* (Gray). The other two genera are monotypic, represented by *Trichiurus lepturus* Linnaeus and *Leputracanthus savala* (Cuvier). The most recent revision places the genus *Eupleurogrammus* under the subfamily Lepidopodinae and the latter two genera under the subfamily Trichiurinae, of the family Trichiuridae (Tucker, 1956).

Our present knowledge about the osteology of the ribbon fishes is very meagre. Gunther (1860) has outlined some general osteological characters of *Trichiurus lepturus* and Starks (1911) and Gregory (1933) have made some remarks on the skull of the same species, while the osteological characters of the other two genera have not been examined so far. Regan (1909) made reference to some general osteological features of Trichiuriformes, including the Trichiuridae and Gemyplidae.

Herein, an attempt is made to make a comprehensive and comparative study of the osteology of ribbon fishes from Indian waters. From this study, it is also aimed to draw a clear distinction between the different species based on osteological characters, as many similarities and differences have been noticed amongst the species under investigation. A brief discussion of these characters and their systematic significance is given, together with an osteological key.

In comparing the osteology of the four species it was noticed that while they have many features in common, two of them viz. *T. lepturus* and *L. savala* share certain characters and stand apart from the two species of *Eupleurogrammus*. Hence a detailed description of the osteology of *T. lepturus* which appears to be the most widely distributed of all four species is given below, and the characters in which other species differ from it are mentioned. A comparison of these with other genera of the family is made, to infer their possible phylogenetic relationship. For this purpose, the works of Allis (1903), De Sylva (1955), Francisco (1956), Gregory (1933), Gunther (1860), Starks (1910, 1911) and Kishinouye (1923) have been a valuable aid.

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MATERIAL AND METHODS

The material for the study has been collected from different fish landing centres along the Indian coast and all the four species have been examined in different sizes. The majority of the fishes examined were obtained from local fish landing places on the Gulf of Mannar and Palk Bay, where three of the species occur together (James, 1959).

Skeletons were prepared for study by cooking the fresh fish in water. It has been found easy first to boil the water and then keep the specimen in it just long enough (about 5 minutes) to loosen the muscles from the bones. The bones of the skull of all species were disarticulated and studied. Alizarin staining technique as employed by Hollister (1934) referred to by Clothier (1950) was used with slight modifications to study the skeleton *in situ*.

The following procedure has been adopted for alizarin staining, which gave good results : For all preparations 4% KOH in distilled water was used. Staining solution was prepared by the following formula :—

Glacial Acetic acid	..	0.5 c.c.
Glycerine	..	3.0 c.c.
Chloral hydrate	..	10.0 c.c.
Alizarin Stain	..	0.1 gm.

Specimens were first hardened and kept straight in 5% formalin for 10-15 days. They were washed thoroughly under running tap water and then placed in 4% KOH. They take 2 to 4 weeks to become transparent, and ready for staining. The staining solution is added drop by drop to fresh KOH containing the specimens till it showed a violet-pink colour. The specimens take stain in 2 to 7 days depending on the size as well as the species. After they are stained, the used up solution was pippetted out, fresh KOH and increasing quantities of glycerine were added at regular intervals and preserved finally in pure glycerine. At each stage they were kept at least for 48 hours. Young individuals take less time to clear and the bones are much clearer than in older groups. Radiographs of a dozen specimens of each species ranging in size between 25-65 cm. S.L. were also examined.

In naming the various bones of the skeleton Clothier (1950), Ford (1937), Gregory (1933), Gunther (1860), Harrington (1955), Kishinouye (1923), Ramaswami (1952) and Starks (1901, 1910, 1911) were followed.

OSTEOLOGY

The very elongate, narrow shape of the skull (Figs. 1 and 2) reflects the highly carnivorous nature of these fishes. The bones of the skull are thin, except those of the jaws. Gunther (1860), and Starks (1911) have remarked that the skull of *T. lepturus* is very similar to that of *Lepidopus* Gouan and *Aphanopus* Lowe belonging to the two other sub families under Trichiuridae. Gregory (1933) has drawn attention to the close similarity of the skulls of *Trichiurus* Linnaeus and Gempylids. Except for minor details the skulls in the other two genera viz. *Eupleurogrammus* and *Lepturacanthus* also resemble those of *Lepidopus* and *Aphanopus*.

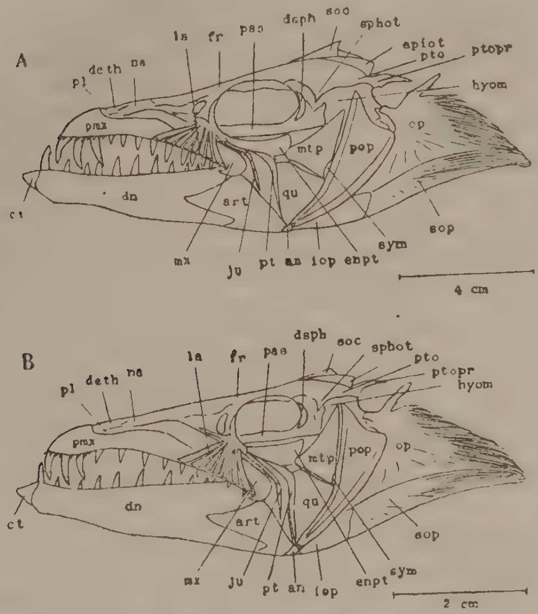


FIG. 1. Skull, lateral view. A. *Trichiurus lepturus*. B. *Lepturacanthus savala*.

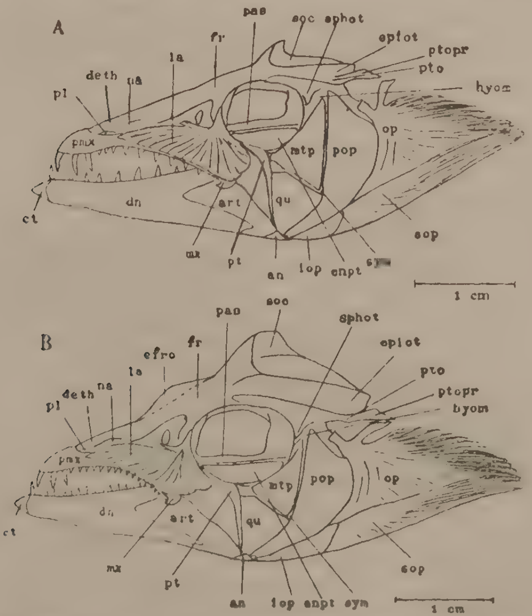


FIG. 2. Skull, lateral view. A. *Eupleurogrammus intermedius*. B. *Eupleurogrammus muticus*.

The main features of the skeleton may be summarized as follows : Bones thin and light ; neurocranium elongate and laterally compressed ; supraoccipital crest low ; posterior confluence of the frontals elevated to a median crest ; dorsal surface of the skull with grooves and ridges posteriorly ; dermethmoid cylindrical, forked posteriorly ; vomer devoid of teeth, broad at the anterior end and tapering to a sharp point posteriorly ; nasals long, and narrow ; maxilla broadest at the posterior end and premaxilla at the anterior end ; lower jaw tipped with a triangular piece of cartilage ; premaxilla and dentary forming upper and lower margins of the mouth cleft ; maximum of 3 canine-like barbed teeth anteriorly on each premaxilla and one on each dentary, the latter tooth remaining outside when the mouth is closed ; these followed by variable number of smaller and simpler teeth on both jaws ; palatine teeth in series or in villiform band ; suborbital ring incomplete, lacrymal most prominent, membranaceous and sculptured ; head of hyomandibular cruciform ; margins of opercle and subopercle fringed ; preopercle strong and bony with prominent ridges in the shape of ' Y ' ; pterotics produced posteriorly into spine-like processes ; alisphenoids, simple, triangular ; number of gill rakers variable and prominent on the outermost arch ; vertebrae numerous, extending to tip of tail ; ribs fragile ; interneurals and interhaemals usually correspond to neural and haemal spines ; pelvic girdle and fins absent or reduced ; dorsal and anal fin rays numerous.

NEUROCRANIUM

The neurocranium (Figs. 3-7) in the three genera is long and narrow, broadest at the posterior end. The dorsal surface is more or less flat in *T. lepturus* and *L. savala* while it is convex in *Eupleurogrammus*. The dorsal profile in a complete specimen is sharply declevous to the snout from nape in *E. muticus*. Along the dorsal surface, the median ridge is not prominent except at the supraoccipital region. On either side are three grooves, separated by 2 ridges of bone, viz. the dilator, temporal and supratemporal grooves extending from the outer to the inner regions of the skull

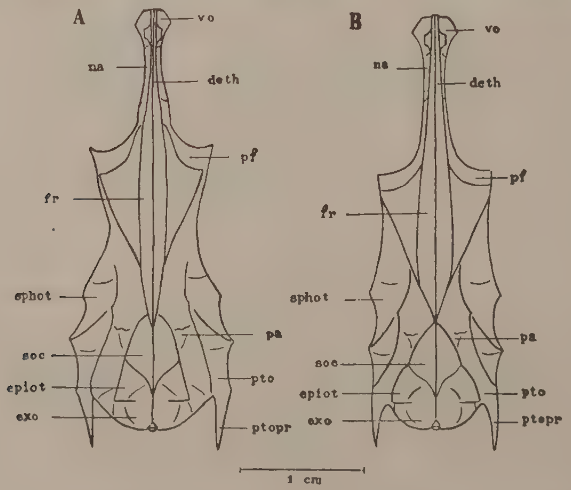


FIG. 3. Neurocranium, dorsal view. A. *T. lepturus*. B. *L. savala*.

respectively. Unlike in *E. intermedius* the median ridge is carried forward by the frontals to the dermethmoid (ethmofrontal crest) in *E. muticus*, such a prominent crest being absent in the other two species resulting in lesser height of the neurocranium and consequently of the head. The supraoccipital crest is very feeble in all the species.

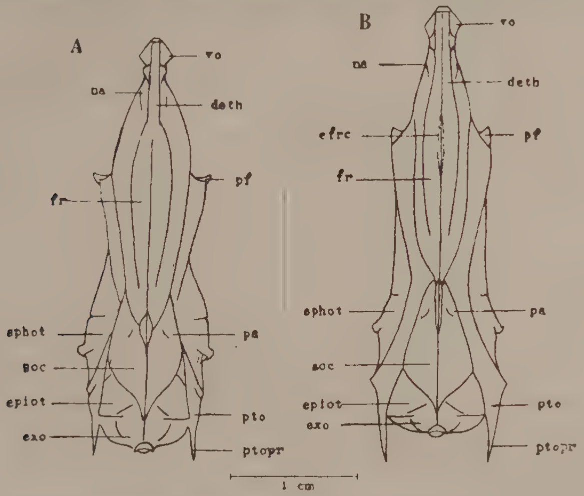


FIG. 4. Neurocranium, dorsal view. A. *E. intermedius*. B. *E. muticus*.

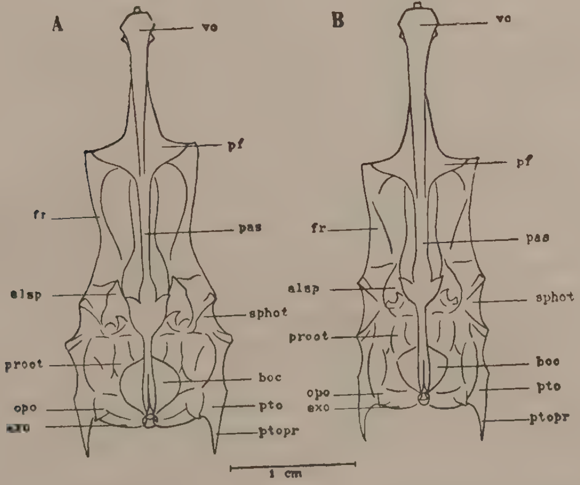


FIG. 5. Neurocranium, ventral view. A. *T. lepturus*. B. *L. savala*.

The grooves and ridges present a variable pattern over the dorsal surface of the skull. They are well defined only in *T. lepturus*. The temporal and pterotic ridges are quite distinct and run more or less parallel. The *temporal ridge* in *T. lepturus* stops short and fades into the general surface at about the posterior confluence of frontals. It presents posteriorly a flap-like projection whereas the outer terminates laterally and anterior to pterotic. In *L. savala* the ridge is much shorter and stops short anteriorly at the lateral mid-portion of supraoccipital presenting a flap-like projection posteriorly as in *T. lepturus*. In *E. intermedius* this ridge runs forward and terminates at the posterior end of the nasal, while in *E. muticus* it curves laterally merging with the general surface about the middle region of the orbit. The external or *pterotic ridge* in *T. lepturus* extends forward to the mid-level of the orbit and fades into general surface. Posteriorly it merges with the lateral side of the pterotic bone. In its anterior course, it is deeply curved and runs parallel to the frontal ridge. In *L. savala* this ridge is very similar to that of *T. lepturus* but the anterior extremity is not parellel to the frontal ridge and being apparently approximated with the latter. The external ridge is very short in *E. intermedius* and it unites with the internal ridge at the level of supraoccipital to continue forward to the nasal. A similar condition is seen in *E. muticus* where it joins the internal ridge but terminates above the mid-level of the orbit. *The dilator groove* is much deeper and wider in *T. lepturus* and *L. savala* than in the species of *Eupleurogrammus*. The middle or *temporal groove* is broad in *T. lepturus* and very narrow and short in *L. savala* and *Eupleurogrammus*. It is relatively shorter in *E. intermedius* than in *E. muticus*. The groove is the biggest and broadest in *T. lepturus*, but shortest and narrowest in *L. savala* among the four species. The *supratemporal groove* is the widest of the grooves. It is comparatively shallower in *L. savala* than in the other forms.

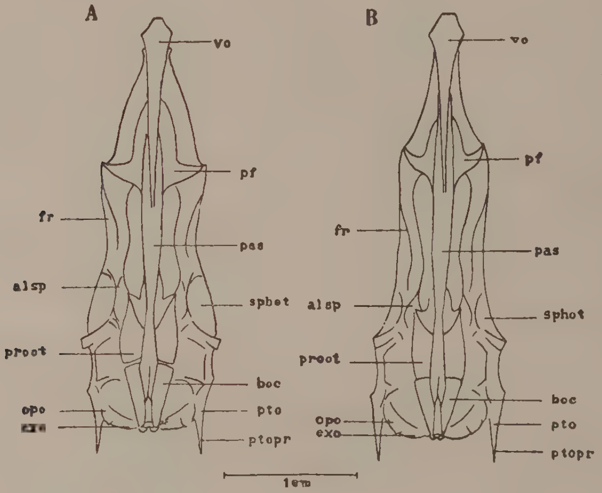


FIG. 6. Neurocranium, ventral view. A. *E. intermedius*. B. *E. muticus*.

The orbits are large in *T. lepturus* about 1/3 length of neurocranium while they are small in *L. savala* measuring less than 1/3 of the neurocranium. They are nearly equal in size in *Eupleurogrammus* species but less than 1/3 the length of neurocranium.

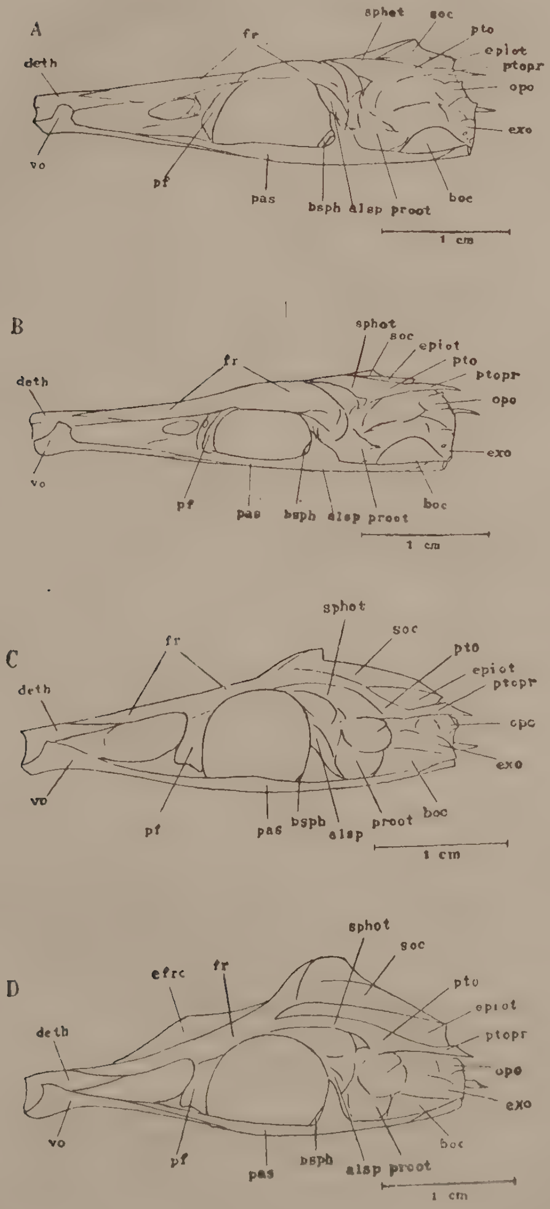


FIG. 7. Neurocranium, lateral view. A. *T. lepturus*. B. *L. savala*. C. *E. intermedius*. D. *E. muticus*.

INDIVIDUAL BONES OF THE SKULL

(Figs. 8-11)

Olfactory Region : The *dermethmoid* (*deth*) is median and forked posteriorly. It is more or less cylindrical enclosing a cavity. Anteriorly it rests over three protruberances of the vomer, and posteriorly overlapped by the anterior ends of frontals. Posterolaterally it is bounded by the prefrontals. At the anterolateral portion the dermethmoid supports the nasals. The anterior tip of the dermethmoid is blunt in *T. lepturus* and *L. savala* while it is sharp in *Eupleurogrammus*.

The *prefrontals* (*pf*) are two irregular bones, forming the anterior wall of the orbit and the posterior mesial walls of the nasal cavity. The bones meet along the median line and articulate above with the frontals, anteriorly with the lateral extensions of the dermethmoid and posteroventrally with the parasphenoid. The anteroventral extension of the bone found in *T. lepturus* and *L. savala* is absent in *Eupleurogrammus*. On the other hand there is a sharp anterodorsal process in *E. intermedius* and *E. muticus* which is absent in *T. lepturus* and *L. savala*.

The *nasals* (*na*) are elongate, flat bones, cemented along their entire length to the anterolateral sides of the dermethmoid. The nasals of *T. lepturus* and *L. savala* are alike and those of *E. intermedius* and *E. muticus* resemble each other. The nasals of the former two species differ from the latter two in that they are longer and slightly bent anteriorly.

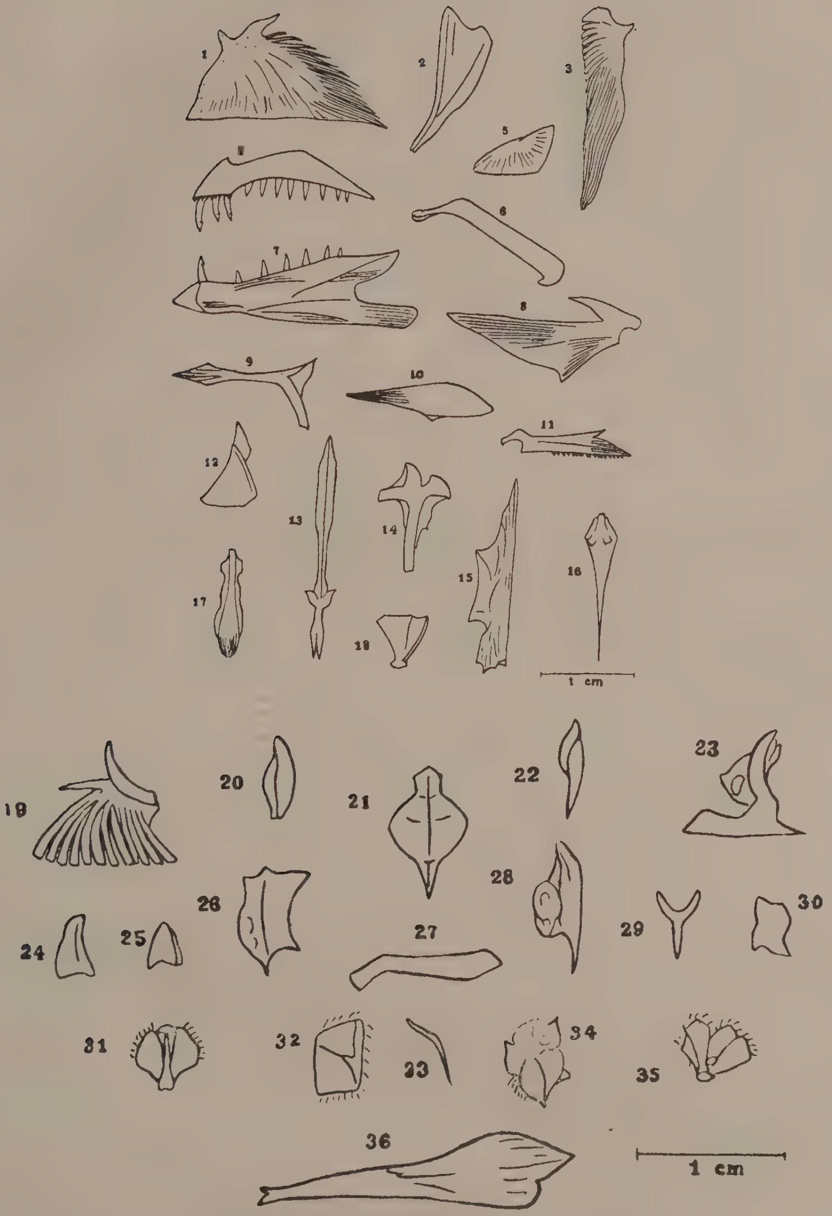
The *vomer* (*vo*) is broad at the anterior end and narrows down to a long process posteriorly which ends in a sharp point. Anteriorly it articulates with the maxilla and posteriorly it lies in the groove on the external side of parasphenoid. It presents three protruberances at the anterior inner extremity, on which the dermethmoid rests. The vomer is devoid of teeth in all species. In *T. lepturus* and *L. savala* the anterior articulatory facet is short and straight while in *Eupleurogrammus* it is long and upturned.

Orbital Region : The paired *frontals* (*fr*) from the largest portion, approximately 2/3 of the dorsal roof of the skull. The bones are pointed anteriorly and cover the bifurcated posterior end of dermethmoid. Posteriorly they are broad. The frontals are closely approximated over their entire length, except at their anterior tips which diverge and partly cover the dermethmoid. The posterior confluence of the frontals is elevated in *T. lepturus* to a low crest which is least developed in *L. savala*, highest in *E. muticus*. The frontal crest in *E. intermedius* resembles that of *T. lepturus*.

Anteriorly the frontals lie over the posterior end of dermethmoid and the dorsal ends of the parethmoids. Laterally they contribute to the roof of the orbit and posteriorly they are connected with the supraoccipital, sphenotics, parietals, alisphenoids and pterotics.

The *alisphenoids* (*alsp*) are paired, small, triangular bones. They form the posterodorsal angle of the orbit wall and articulate with the sphenotics, prootics and basisphenoid. As in all scombroids, they do not articulate with parethmoids.

The brain chamber opens between the alisphenoids. Its aperture is wider in *T. lepturus* than in *L. savala* and is much deeper in *E. muticus* than in *E. intermedius*.



FIGS. 8 and 9. Disarticulated bones. *T. lepturus.*

1. opercle, 2. preopercle, 3. subopercle, 4. premaxilla, 5. interopercle, 6. maxilla, 7. dentary, 8. articular, 9. ectopterygoid, 10. entopterygoid, 11. palatine, 12. metapterygoid, 13. parasphenoid. 14. hyomandibular, 15. frontal, 16. vomer, 17. dermethmoid, 18. quadrate, 19. lacrymal, 20. dermosphenotic, 21. supraoccipital, 22. symplectic, 23. prefrontal, 24. alisphenoid, 25. parietal, 26. sphenotic, 27. nasal, 28. pterotic, 29. basisphenoid, 30. opisthotic, 31. basioccipital, 32. epiotic, 33. jugal, 34. prootic, 35. exoccipital, 36. urohyal.

The parasphenoid (*pas*) is more or less similar in shape in all the genera and species. The part of the parasphenoid opposite the orbital cavity (when the neurocranium is viewed ventrally) is slightly broader in *Eupleurogrammus* than in the other two genera.

The *lacrymal* (*la*) is the largest bone of the suborbital ring and is characterized by the sculpture which decorates it. It consists of a dorsal bony rod and a membranous fringed flap. A curved dorsal process from the bony rod binds the anterior margin of the eye. The membranous part hides from view the major portion of the maxilla and the premaxilla on each side. The lacrymal differs strikingly in shape and relative size, in the two sub-families. In *Trichiuris* and *Lepturacanthus* it is short, high and fan-like covering only about one-third of premaxilla and maxilla while in *Eupleurogrammus* it is comparatively large covering a greater portion (about two-thirds the length) of premaxilla and maxilla.

The second element of the suborbital ring is represented by a delicate bent bone, the *jugal* (*ju*) in *T. lepturus* and *L. savala* and unrepresented in *Eupleurogrammus*. It is situated immediately behind the lacrymal.

A third ossicle, the *dermosphenotic* (*dsph*) is crescent-shaped, freely suspended, small bone with an inward wing-like extension situated centrally at the posterior margin of the orbit, apparently forming the suborbital shelf. This bone is also not represented in *Eupleurogrammus*.

Otic Region : The *parietals* (*pa*) are paired small bones on the anterior sides of the supraoccipital and bear dorsally a small elevated ridge, which forms part of the temporal ridge. Anteriorly the parietals unite with the frontals and posteriorly with the epiotics. The parietals do not take part in the formation of the roof of the brain cavity, and are similar in all the genera.

The *supraoccipital* (*soc*) forms dorsally the median portion of the posterior end of the neurocranium. It is convex above, broadest in the middle and narrower at either ends. The posterior blunt end of it extends between the epiotics. The supraoccipital bears a ridge middorsally, its ridge separating the supratemporal grooves of the two sides. The supraoccipital is bounded anteriorly by the frontals, anterolaterally by the parietals and laterally by the epiotics. The posterior confluence of the frontals is elevated to a dorsomedian crest, more conspicuously in *Eupleurogrammus*. The posterior end of supraoccipital is somewhat blunt in *T. lepturus* and *L. savala* while it ends in a sharp point in *Eupleurogrammus*. In the latter the ridge is confined to the anterior end of supraoccipital in continuation with the posterior confluence of frontals. It is low in *E. intermedius* but high in *E. muticus*, in which it is more strikingly seen in a lateral view of the skull.

The supraoccipital in several specimens of *T. lepturus* of various sizes from different localities was found to be subject to excessive thickening while the absence of this phenomenon in the other three species appears significant, as shown in a recent study (James, 1960).*

The *pterotics* (*pto*) form the posterolateral corners of the skull and are produced into short spine-like processes on either side. They also contribute to the formation of the temporal and dilator grooves and to the main portion of the pterotic ridge.

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* Bhatt and Murthi have referred to this subject in a recent paper. (*J. Univ. Bombay*, vol. **28** (5) : 84-89, 1960).

The pterotics bear anterior processes in *Eupleurogrammus* which are absent in the other two genera.

The *prootics* (*proot*) are irregular bones prominent on the ventral side of the neurocranium. The prootics in all the species are alike in shape and disposition and articulate with the parasphenoid, sphenotics, pterotics and basioccipital.

The *epiotics* (*epiot*) are two small bones, each with a dorso-lateral and a posterior surface intervened by a thin transparent area. Dorsally a process receives the upper branch of the post-temporal, thus forming a connection between the pectoral girdle and neurocranium. This process at the posterior end of the temporal ridge is equally prominent in all the species.

Anteriorly and along the median line the epiotics join the supraoccipital, posteriorly they unite with the exoccipitals and laterally with the pterotics.

The *sphenotics* (*sphot*) form the posterior part of the orbital roof and laterally a segment of the articular fossa for the head of the hyomandibular. The shallow open dilator grooves traverse the surface of the sphenotics. In *T. lepturus* and *L. savala* the sphenotic bears a prominent dorsal ridge which is lacking in *Eupleurogrammus* species. The lateral margin of sphenotic presents a concavity in the two former species while it is entire in the latter forms. In all cases there is an inward extension of this bone overlapped by the posterior end of the frontals. The sphenotics are flattened bones and bear a postero-lateral projection in all species.

The *opisthotics* (*opo*) are small scale-like bones interposed between the pterotics and the exoccipitals.

The *exoccipitals* (*exo*) are fan-shaped bones which enclose the foramen magnum and articulate with the basioccipital along the median line. Anteriorly they join the prootics, and laterally the pterotics. Their vertebral or paraoccipital condyles to the atlas are concave, and project beyond the basioccipital. The ventral surface is slightly concave and bears a prominent aperture or the foramen for the passage of the vagus nerve.

Basicranial Region : The *parasphenoid* (*pas*) is a long rod-like bone that forms the greater portion of the basicranial region of the neurocranium. It extends the entire length of the ventral median line between the olfactory region in front and otic region behind. The parasphenoid is long and bears posteriorly two small lateral ascending wings, one on either side to connect the prootics. Behind these wings the parasphenoid is constricted and gradually broadens with a gentle curvature upwards. At the sharp posterior bifurcated end the parasphenoid is embraced by the ventral sides of the basioccipital, and the median spine-like process of the latter fits into its forked end. The anterior end is simple and grooved externally for a distance, where it is overlapped ventrally by the posterior portion of the vomer. The portion between this point and the point of origin of lateral wings is the narrowest part of parasphenoid and forms the ventral margin of orbital cavity. The middle portion of the parasphenoid (ventral margin of orbital cavity) is narrow in *Trichiurus* and *Lepturacanthus* but broad in *Eupleurogrammus*. In *E. muticus* it is relatively broader than in *E. intermedius*.

The *basisphenoid* (*bsph*) is a small median Y-shaped bone, which unites the parasphenoid with the prootics and alisphenoids. The median vertical process is laterally compressed. The basisphenoid is very much alike in all the species, but greatly exposed in *T. lepturus* in a lateral view of neurocranium than in the other species.

The *basioccipital* (*boc*) is a short narrow bone with two wing-like extensions. It bears the concave rounded occipital condyle that articulates with the atlas. The median portion which is spine-like, fits into the forked posterior end of parasphenoid. The anterior end is broader than the solid posterior end.

The basioccipital supports dorsally the exoccipital of the corresponding side of the neurocranium and is bounded ventrally by the parasphenoid and in front by the prootics. The vertebral or paraoccipital condyles of the exoccipitals to the atlas rest on the hind end of basioccipital.

The shape and size of basioccipital varies in the different genera. In *Trichiurus* and *Lepturacanthus* it is short and broad especially at the anterior end. In *Eupleurogrammus* it is long and narrow, with the lateral wings less expanded at their anterior ends.

Except for the differences mentioned above, the basicranial bones are much similar in structure in all the three genera of ribbon fishes.

BRANCHIOCRANIUM

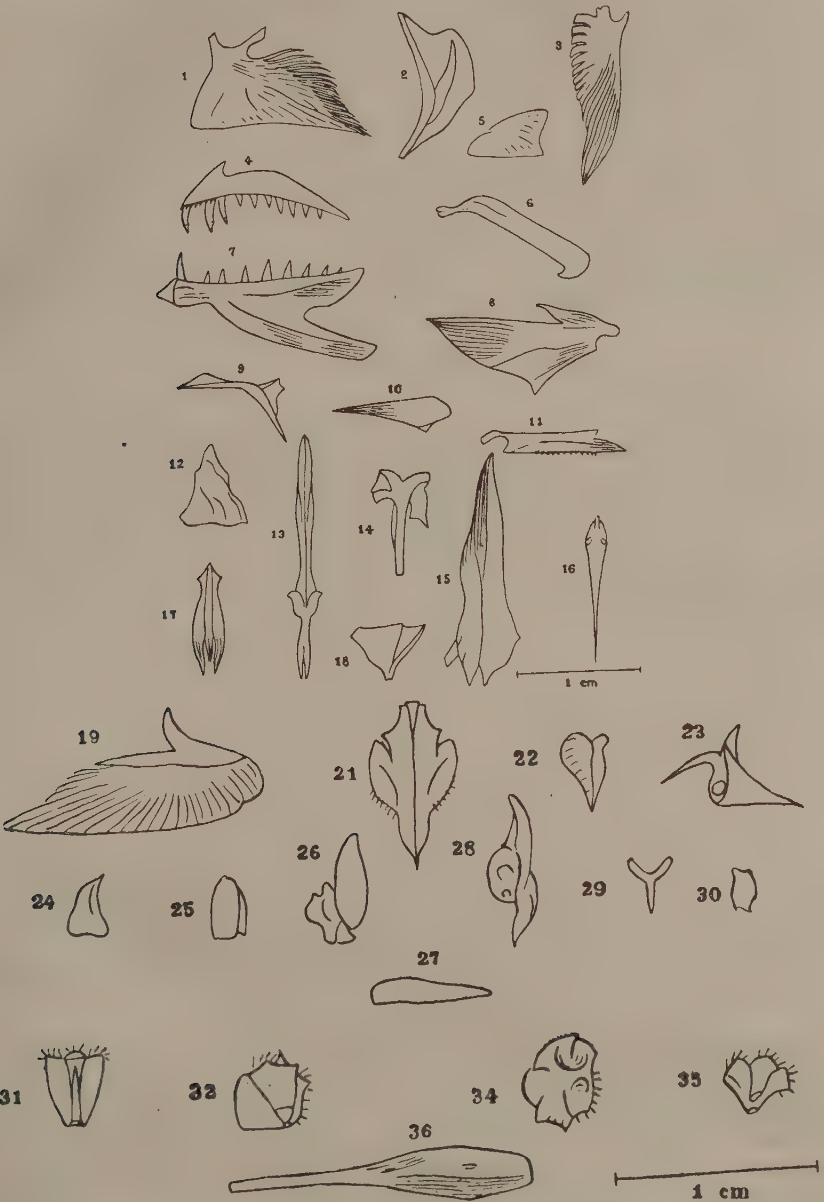
Oromandibular Region : The *premaxilla* (*pmx*) is a long curved bone tapering anteriorly and posteriorly. The bone is thickest at the anterior end, with an ascending process. The ascending process is more pointed in *Eupleurogrammus* than in *Trichiurus* and *Lepturacanthus*. The nasal process of the premaxilla projects into the concavity in front of and over the dermethmoid.

The number of premaxillary teeth is variable in the species. Of the four species, *Eupleurogrammus muticus* bears the maximum number of teeth and *Lepturusanthus savala* the minimum. A detailed study of the oral armature in the Indian Trichiurids in correlation with their feeding habits will be published elsewhere. However, brief details are given in Table I for comparison.

In the angle between the posterior margin of the ascending nasal process of the premaxilla and the dorsal edge of the shank of the bone there is a small backwardly directed process or projecting edge which has two depressions or articular facets, one on either side. The edge fits into the anterior forked cartilaginous part of the maxilla, while the two cartilaginous pieces of the latter lie firm in the two facets.

The *maxilla* (*mx*) is also a long, curved bone, the inferior surface of which lies over the superior surface of premaxilla behind the ascending process of the latter and extends beyond its posterior end. The head of the maxilla ends in a bifurcated cartilaginous piece, the two portions of which embrace the backwardly directed process of the premaxilla, while the cartilaginous pieces lie in depressions on either side. The maxilla is laterally compressed and is relatively broader at its posterior end.

The *dentary* (*dn*) is a large posteriorly forked bone, which forms the basis of the lower jaw, and like the premaxilla and maxilla it is laterally flattened. It bears a single row of triangular, sharp teeth on the dorsal arm. The ventral arm is relatively



FIGS. 10 and 11. Disarticulated bones. *E. intermedius*. Order of numbers as in Figs. 8 and 9. Numbers 20 and 33 absent.

narrower but longer than the dorsal one and both arms are covered by the anterior end of articular. The anterior end of dentary is joined with its fellow of opposite side by means of a symphysis. At the symphysial region, the lower jaw is tipped with a small conical piece of cartilage. The dentary is very much alike and the lower jaw is uniformly tipped with cartilage in all four species. The jaws are subequal the lower being longer.

The *articular* (*art*) is more or less a spear-shaped bone, which is concave internally and convex externally, its concavity corresponding to the convexity of the dentary partly overlapped by the former. The posterior end of the articular bears 3 processes, the uppermost directed antero-dorsally, the lower directed antero-ventrally and the third directed posteriorly the last of which articulates with the head of quadrate. The articular is similar in general shape in all the species, except in *Eupleurogrammus* where it is broader with the dorsal process diverging less distinctly from it.

The *angular* (*an*) is a small bone attached to the posterior end of articular.

The *metapterygoid* (*mtp*) is a flat bone, triangular in shape. Its postero-dorsal margin presents a fringe or appendage of bone for the articulation of the stem of the hyomandibular, its anterior margin being entire. The ventral margin is also straight and borders the quadrate and symplectic. The dorsal narrow portion of the metapterygoid articulates firmly with the anterior lower angle of hyomandibular. The stem of the hyomandibular runs adjoined with the posterior margin of the metapterygoid. The metapterygoid is similar in all the species, but in *T. lepturus* and *L. savala* the posterior margin is more convex than in *Eupleurogrammus.*

The *ectopterygoid* (*pt*) is a T-shaped bone, the top of ' T ' forming its posterior end. The ectopterygoid is joined with the entopterygoid dorsally, with the palatine laterally and anteriorly and with the quadrate and metapterygoid posteriorly. The shank of the ' T ' is grooved anteriorly, with concavity situated dorsally and convexity ventrally opposing a concave narrow fringed anterior portion of the entopterygoid. The ventral convexity of the anterior end of ectopterygoid forms part of the roof of buccal cavity. The ectopterygoid is alike in all the species.

The *entopterygoid* (*enpt*) is a long typically thin papery bone which connects with the palatine, metapterygoid and ectopterygoid and lies on the parasphenoid with its mesial and posterior edges free. The dorsal surface is concave. The entopterygoid differs slightly in shape in the different species. In *Trichiurus* and *Lepturacanthus* the broadest portion of the entopterygoid lies about the mid length of the bone whereas its anterior end is much sharper and posterior end broader in *Eupleurogrammus*. The ventral surface is smooth in all species.

The *palatine* (*pl*) runs forward on the external side of the vomer and hooks over the anterior end of the maxilla, immediately ventral to the nasal. Along the ventral edge, the palatine is armed with fine teeth. At the anterior end the palatine presents a hook-like process, strongly curved down in *T. lepturus* and *L. savala*, while it is just bent down in *Eupleurogrammus*. Posteriorly the palatine is broader and connects with the entopterygoid and ectopterygoid. The arrangement of the teeth on palatines varies with the genera. In *Trichiurus* and *Lepturacanthus* they are in the form of a villiform band, teeth being more prominent in *L. savala*, while in *Eupleurogrammus* they are arranged in irregular series.

The *quadrate* (*qu*) is a triangular bone with two prominent V-shaped ridges on the inner side. It is more or less a central bone, articulating dorsally (by its broadest side) with the metapterygoid and the stem of hyomandibular, posteriorly with the preopercle and ventrally with the articular and angular, the last two presenting a depression for the articular head of quadrate. Antero-dorsally, the quadrate is connected with ectopterygoid. Along the posterior margin, there is a thickened portion, grooved on its inner surface appearing as a strong spine-like process, directed upwards. This ridge or process provides articulation for the preopercle. The quadrate is broader than high in *Eupleurogrammus* and the reverse holds good, in *T. lepturus* and *L. savala.*

The groove on the inner surface of the quadrate lodges the *symplectic* (*sym*) a small, narrow bone which is scarcely visible externally and can be seen clearly when the quadrate is viewed from inside. The dorsal projecting portion of symplectic articulates with the lower end of hyomandibular.

Hyoid-Opercular Region : The *opercle* (*op*) is a thin bone, roughly triangular in shape. The anterior superior and middle portions are thicker than the rest of the opercle. Dorsally and anteriorly there are two processes, the shorter directed anteriorly to articulate with the opercular process of hyomandibular and the longer directed posteriorly. The superior and posterior free margins of opercle are finely fringed. Its anterior margin is plain, overlapped by the hind edge of preopercle and its ventral margin joins the dorsal border of subopercle.

The *subopercle* (*sop*) is a long, narrow, thin bone, broad anteriorly and narrow posteriorly. It is fringed along the posterior and inferior margins. Anteriorly it bears a small process, directed forward and upward to articulate with the preopercle. The bone is longer and narrower and inferior margin of the subopercle is concave in *Trichiurus* and *Lepturacanthus* while it is broader and the inferior margin convex in *Eupleurogrammus.*

The *interopercle* (*iop*) is triangular in shape and thin like the opercle and the subopercle, but very much smaller than the two. It forms the anterior and inferior free margin of the gill cover and along its inner surface it articulates with the ceratohyal. The dorsal margin of interopercle is overlapped by the ventral posterior margin of the preopercle and the posterior margin joins the subopercle and partly the opercle (at its posterior dorsal corner). The bone is essentially similar in all species except for the more convex dorsal margin in *Eupleurogrammus.*

The *preopercle* (*pop*) is a characteristic wing shaped bone, differing strikingly from all the other bones of the opercular complex. It is very bony and strongest of all the opercular bones, broad above and narrow ventrally. There are two strong bony ridges in the shape of ' Y ' along anterior and posterior margins which are highly prominent on the inner surface. The posterior edge of preopercle overlaps the opercle and the subopercle, while its anterior margin with the ridge and a groove lies in juxtaposition with a similar ridge of the hyomandibular, articulating with the latter and also with the symplectic and the quadrate. The preopercle is similar in general shape in all the species, but is somewhat broader and shorter in *Eupleurogrammus* than in the other two genera.

The *hyomandibular* (*hyom*) is typically cruciform with three condyles, two of them for articulating with the neurocranium by means of two facets, one in the postero-inferior face of the sphenotic and the other on the ventral surface of the pterotic. The third condyle articulates with the opercle posteriorly. There is a fringe of bone in the angle of the posterior process and the stem of hyomandibular. The fringe is small in *T. lepturus* and *L. savala* while it is large and directed postero-ventrally ending in a sharp point in *Eupleurogrammus*.

Anteriorly, the ventral surface of the hyomandibular connects the metapterygoid, the symplectic and the interhyal, the last of which is orientated along the axis of the stem. The posterior portion of the stem presents a deep groove which articulates with the anterior surface of the vertical limb of the preopercle.

The stem of the hyomandibular is separated into anterior and posterior portions by a strong ridge which extends from the ventral end upward and forward in a slightly curved line. Between the ventral margin of the anteriormost condyle and the anterior margin of the stem of the hyomandibular below it, there is a narrow bony lamella.

The *hyoid arch* or *cornu* (Fig. 12, A-D) in all the four species contains in addition to the glossohyal, which is embedded in the tissues of the tongue, four separate bones, the basihyal, ceratohyal, epihyal, and interhyal. These pieces are connected by plain joints and fibrous connections. The interhyal articulates the complex posteriorly with the hyomandibular and symplectic, while the basihyal connects the anterior end to its fellow of the opposite side and to the anterior extremity of the first basibranchial of the branchial arch.

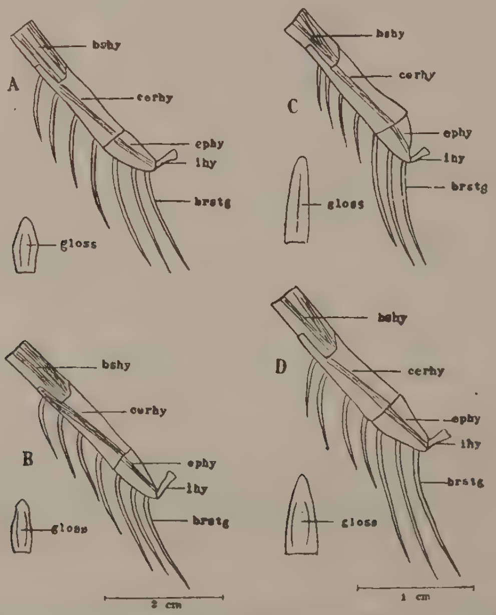


FIG. 12. Hyoid arch and glossohyal. A. *T. lepturus*. B. *L. savala*. C. *E. intermedius*. D. *E. muticus*.

The *glossohyal* (*gloss*) is a flat bone, broad at the base and tapers anteriorly. The glossohyal in *T. lepturus* and *L. savala* is short and broad, while it is very long and gradually tapers in *E. intermedius* but is broader at the base and pointed at the tip, in *E. muticus*.

The *basihyal* (*bshy*) is composed of two centres of ossifications firmly united in a straight line. The two halves are nearly of the same size. The ventral ossification at its posterior end rests over a narrow process of ceratohyal, while a dorsal smaller process of the latter binds the posterior corner of the dorsal half of basihyal.

The *ceratohyal* (*cerhy*) is the largest piece of the complex. It is broader at the posterior portion and slightly concave along its dorsal margin. Four of the *branchiostegal rays* (*brstg*) are attached to respective articular surfaces along its ventral margin. The anterior end of ceratohyal bears two processes, a longer ventral and a shorter dorsal, which articulate with the basihyal. The posterior end of ceratohyal is firmly articulated with the epihyal.

The *epihyal* (*ephy*) is triangular in shape, broad anteriorly and narrow posteriorly where it articulates with the interhyal. The three remaining branchiostegal rays take origin from the ventral margin of epihyal.

The *interhyal* (*ihy*) is a small, narrow bone, which articulates the hyoid complex with the hyomandibular and symplectic and is directed obliquely upward.

The three posterior branchiostegal rays are shorter in *T. lepturus* and *L. savala* while they are comparatively longer in *Eupleurogrammus*.

The *urohyal* (*urohy*) is enlongated and medially located between the basihyals. Its posterior end is laterally compressed, blade-like and embedded free in the muscular mass of the throat. In *Trichiurus* and *Lepturacanthus* the urohyal is much broadened specially the posterior portion, which ends in a sharp point while in *Eupleurogrammus* the urohyal is rod-like and the posterior end is broad but truncated.

Except for the relative length of the posterior branchiostegal rays and the shape of urohyal, the bones of the hyoid complex are very similar in the four species.

Branchial Region : The *branchial arches* (Fig. 13, A-D) are enclosed within the hyoid arch, with which they are connected at the base. They form the support for the gills and are composed of smaller bones. The branchial skeleton in the four species exhibits a similar general pattern as described below :

The three *basibranchials* (bb_1-bb_3) form a linear series along the median line, giving support and attachment to the four branchial arches. The first basibranchial fits into a depression on the posterior face of the glossohyal and laterally it is joined to the basihyals through intervening cartilage. The second and third basibranchials bear deep oblique grooves on each side to receive the first and second hypobranchials, respectively. All the basibranchials are narrowest in the middle region and broader at either end. The first basibranchial articulates with the second by a broad piece of cartilage and the second with the third by a narrow cartilage. The posterior half of the third basibranchial is much broader but narrows down into a process at the extremity. The third basibranchial is slightly larger than the other two.

The *first hypobranchial* (hb_1) arises from the posterior end of first basibranchial. The *second hypobranchial* (hb_2) is articulated at the posterior end of second basibranchial. Both first and second hypobranchials are narrow bones, the latter shorter

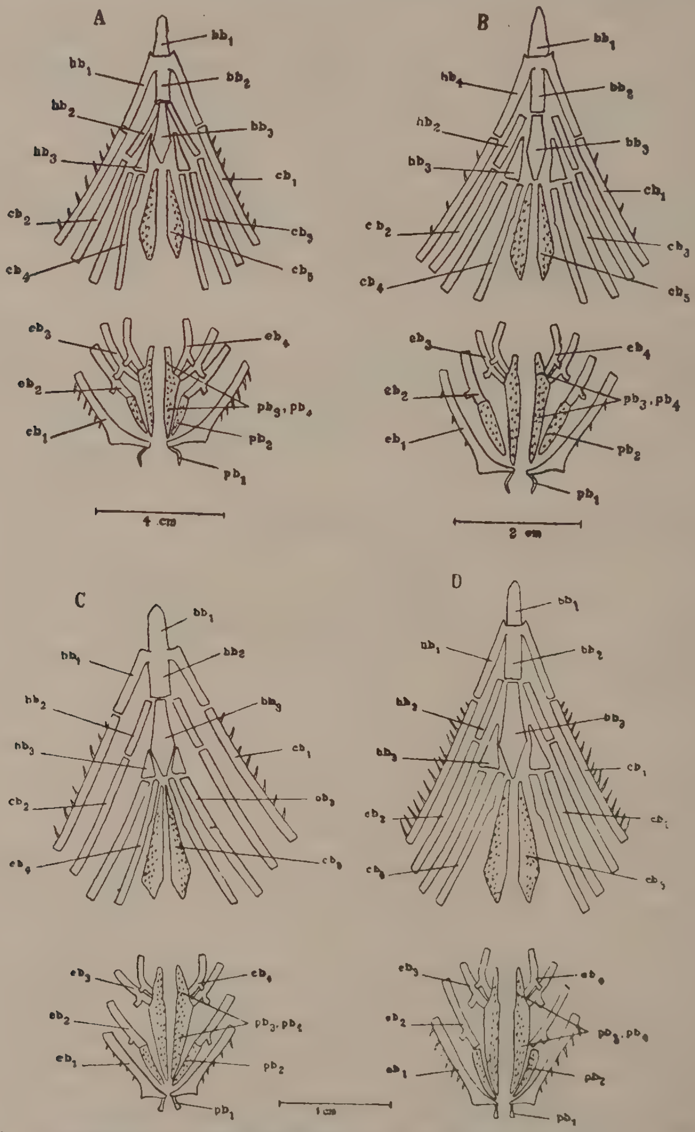


FIG. 13. Branchial arches, ventral half shown above, gill rakers indicated only on the outermost arch. A. *T. lepturus*. B. *L. savala*. C. *E. intermedius*. D. *E. muticus*.

than the former. The *third hypobranchial* (hb_3) is a short triangular bone and differs strikingly, being flat and not rod-like as the other two. They lie adjacent to the posterior end of third basibranchial.

The *ceratobranchials* (cb_1-cb_5) are very long, narrow, gently curved constituting the major support of the lower or ventral half of the branchial arches. The ceratobranchials decrease in length from the first to the last, but are similar in shape, except the fourth which is slightly twisted at its anterior end. The ventral surfaces of ceratobranchials are deeply grooved to their full length.

The *epibranchials* (eb_1-eb_4) form a series of four irregular curved pieces of bone, which are the main support to the upper or dorsal half of branchial arches. The fourth piece is the most internal, very narrow and bent while the other three are gently curved. All four elements are forked at their anterior ends.

The lower pharyngeals or modified *fifth ceratobranchials* (cb_5) bear villiform teeth in a patch along the outer margin.

The four upper pharyngeals or *pharyngobranchials* (pb_1-pb_4) are unequal in size and also bear fine teeth, except the first (suspensory pharyngeal) which is a tiny rod-like bone. This suspensory pharyngeal connects posteriorly the branchial arches to the neurocranium on its ventral side. The second upper pharyngeal is a flat wing-like bone articulating with the second epibranchial. The third and fourth upper pharyngeals are more or less united to form a single long piece on each side, and they articulate posteriorly with the last two of the epibranchials.

At their external margin the first epibranchial and all the ceratobranchials except the innermost bear a series of gill rakers, prominent and better developed only on the outermost arch. It may, however, be mentioned here that they are least developed in *L. savala* and best developed in *E. muticus*. The gill rakers are teeth-like, sharp and pointed, more or less straight sometimes with smaller, accessory spines. The number of gill rakers is quite variable among the species as shown in Table I. The surface of the extremities of the branchial arches is denticulated.

PECTORAL GIRDLE AND FIN

The *pectoral girdle* (Fig. 14, A-D) is situated close behind the neurocranium, and is connected with its upper part by the post-temporal.

The *post-temporal* (*ptm*) is a forked bone which affords the principal articulation of the pectoral girdle to the neurocranium. Its anterior end is divided into a long and sharp dorsal process and a short and blunt ventral process. The dorsal branch articulates with the epiotic, and the ventral lies over the pterotic. The posterior portion of the post-temporal is broader than either of its anterior processes. The post-temporal is alike in all the four species.

The *supracleithrum* (*supcl*) is a rod-like bone, broad and rounded at its anterior end, where it articulates with the posterior end of the post-temporal. Its posterior end rests on the dorsal part of the cleithrum. The supracleithrum is similar in *T. lepturus* and *L. savala*. In *E. intermedius*, it is straight and rod-like with a blunt posterior end, while in *E. muticus* it is slightly bent medially broader and sharper at the posterior end.

The *cleithrum* (*clt*) is a strong bent bone, being the largest of the bones of the pectoral girdle. Its ventral portion is broader and is folded back to present a concavity on the inner side. The cleithrum is similar in all the species, except that it is slightly broader at its upper portion, over the bent, in *E. muticus*.

The *scapula* (*scap*) is a small bone, articulating with the cleithrum on its inner side about the angle of the bent. It is pierced by a foramen, which is oblong in *T. lepturus* and *L. savala*, and roughly triangular in *Eupleurogrammus*.

The upper part of the scapula is thickened to receive the four *pterygials* (*ptryg*) which support the pectoral fin, the one at the base of the pectoral spine, being the largest.

The *coracoid* (*cor*) joins the scapula above, and ventrally articulates with the tip of the cleithrum. The dorsal portion is expanded and the ventral portion is rod-like. The shape of the coracoid is much alike in all except *E. muticus* in which it strikingly differs, the ventral portion being blade-like and flattened, instead of being rod-like.

The *postcleithrum* (*pcl*) is a fine rib-like process arising from the inner side of the cleithrum. It is directed posterior and downwards. It is more abruptly bent at its middle in *T. lepturus* and *L. savala* than in *Eupleurogrammus* species. Its posterior end surpasses vertical below 9th dorsal fin ray in *T. lepturus*, extends to or surpasses vertical below 8th dorsal fin ray in *L. savala*, extends to below 8th dorsal fin ray in *E. intermedius* and surpasses vertical below 8th dorsal fin ray in *E. muticus*.

Significantly enough the pectoral fin consists of one spine (*psp*) and ten branched rays (*ptr*) in all the four species. The pectoral spine is often serrated (Fig. 14, A) along its outer margin the serrations pointing downwards in some individuals of *T. lepturus* and *L. savala*, a condition, not met with in innumerable specimens of both species of *Eupleurogrammus* examined. It was also found that it has no relation with sex. The entire length of the spine except the base, bears the serrations which are more pronounced at the base than at the tip. The pectoral fins characteristically stand vertical and so close to the operculum that they are partly overlapped by it in all the species.

The pectoral fin differs in shape and height in the different species. The fin is relatively longer and reaches nearly the dorsal margin of the body in *T. lepturus* and *L. savala*, while it is much shorter in *Eupleurogrammus*. In the former two species the difference in height between the anteriormost and posteriormost rays (uppermost and lower-most rays) is not significant while in *Eupleurogrammus* species it is very striking, the rays falling rapidly in height. This difference in height of the rays gives the fin a characteristic shape in each of the groups (Fig. 14, A-D).

Pelvic Girdle and Fin

Pelvic girdle and fins are lacking in *T. lepturus* and *L. savala*. In *Eupleurogrammus* species the *pelvic girdle* (Fig. 15, A,B) is a much modified and rudimentary structure represented by a bony rod (*pelv*) equivalent to the pelvic bones, and the fins by two reduced scale-like structures. The pelvic girdle is embedded free in the flesh of the abdominal wall and it consists of two halves. The anterior half is much shorter than the posterior. The basal portion of the anterior half is flattened out and the sides are folded back to enclose a groove and two lateral projections. The anterior end of the posterior half is broader and at this level are suspended the pelvic fins. Both extremities of the pelvic girdle end in fine points. The girdle appears long in *E. muticus* than in *E. intermedius*.

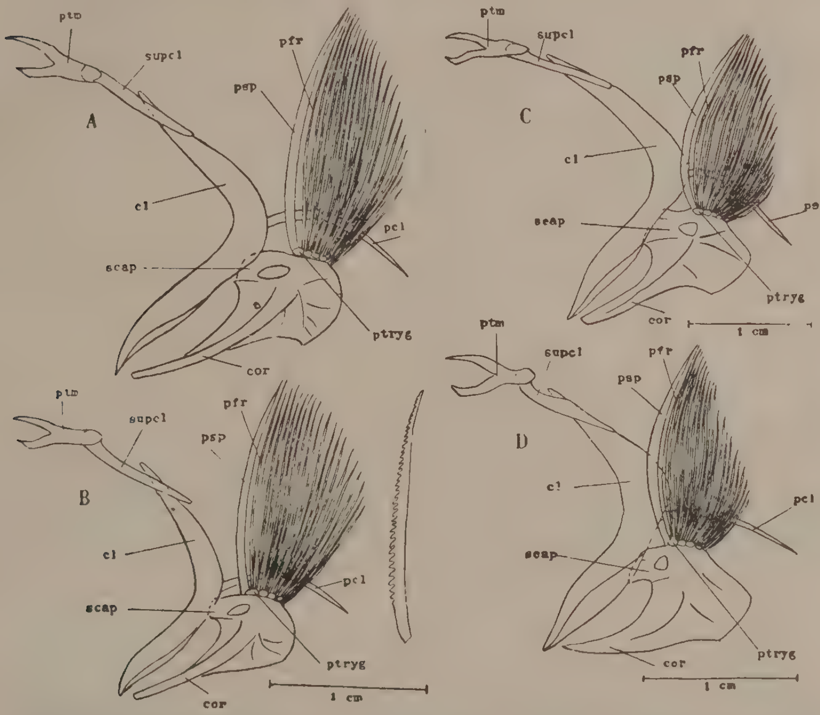


FIG. 14. Pectoral girdle and fin. A. *T. lepturus*. Serrated pectoral spine shown separate. B. *L. savala*. C. *E. intermedius*. D. *E. muticus*.

The pelvic fins are two scale-like structures, directed posteriorly and situated about midway between tip of lower jaw and vent. They lie flush with the abdominal wall. The fins are comparatively bigger and triangular in *E. intermedius*, whereas they are oval and small in *E. muticus*. In general, the degree of reduction and rudimentary nature of the pelvic girdle and fins seems to be greater in the latter than in the former species.

DORSAL FIN

The *dorsal fin* (Pl. I, 1-4) is characteristically long in all the four species originating immediately behind the occipital crest and extending for a greater length along the dorsal margin of the body, towards the tip of the tail. It is low at the anterior and posterior ends, reaching its maximum height at a point opposite or slightly behind the anal region.

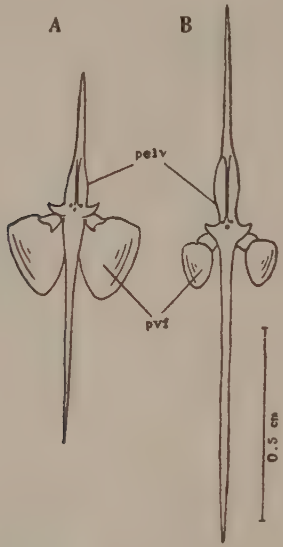


FIG. 15. Pelvic girdle and fins.
A. *E. intermedius*. B. *E. muticus*.

The fin consists of 3 anterior spines in *T. lepturus* and *Eupleurogrammus* while they are 4 in *L. savala* followed by simple rays. Table I gives the range in variation of the rays, in the species. The posteriormost few rays are usually very small and not easily detectable in fresh specimens. They are accurately enumerable only by help of radiographs or by alizarin staining.

Each radial of the dorsal fin consists of three pterygiophores, the proximal, middle and distal. The proximal or the first pterygiophore (interneural) is by far the largest and prominent of the series and forms the essential support of the fin ray. Each interneural is a long stiff spine, the distal portion of which, along the dorsal margin of the body, is compressed from side to side with a short horizontal portion and provides articulation for the one preceding and succeeding it. Each interneural bears a transparent lamellar portion connecting the horizontal and vertical portions, on the anterior side. A large oval foramen perforates the lamellar portion, close to the angle of the horizontal and vertical limbs. The interneurals articulate below with the neural spines. Certain interneurals in some specimens of *T. lepturus* were occasionally thickened and give the appearance of 'stones'. Their occurrence, nature and significance have been discussed elsewhere (James 1960).

The middle pterygiophore is a small piece of bone, more or less triangular in shape and lies in line with the horizontal limb of the first. It fits in tightly over the posterior portion of the horizontal limb of the interneural with which it lies in a line and the anterior portion of the horizontal limb of the succeeding interneural.

The distal pterygiophore is equal in size with the middle and for the greater portion concealed by the two halves of the clasping base of the fin ray, except for its condylar basal (proximal) portion which abutts on the little concavity at the posterior end of the middle piece. This ball and socket like articulation affords a free movement of the fin ray. The distal portion of this pterygiophore (which is clasped in between the two halves of the base of the fin ray) is flattened antero-posteriorly, and is distinctly seen in an anter or view of the fin ray. It still retains its supporting function and as stated above, provides for free motion of the fin ray, although it is known to have lost its function in most of the scombroidae. The three pterygiophores articulate consecutively, though not in a vertical line.

There is usually a regular correspondence between the number of interneurals and the neural spines (hence indirectly with the number of vertebrae) excluding the first or atlas vertebra. Certain irregularities in this relation between the vertebrae and the neural spines and dorsal fin rays are mentioned elsewhere in the text.

Each fin ray consists of a base and along flexible hair-like filament, with the two lateral halves of the latter firmly united. The base of each ray is compressed laterally and more or less spherical in shape. Between the two halves of the base of the fin ray lies the distal portion of the third pterygiophore with which the fin ray articulates.

The structure of the dorsal fin is essentially the same in all the four species of ribbon fishes.

Anal Fin

The *anal fin* (Pl. I, 1-4) commences slightly behind the vent and runs midventrally towards the tip of the tail. The anal fin extends beyond the point of termination of the dorsal fin, in all the species.

The species differ in the structure of their anal fins. In all the species, the spinous anal is represented by two anterior spines (the 2nd spine variously modified) and the soft anal by a varying number of modified fin rays, in the form of spinules, which may or may not break through the mid ventral line of the body.

The first anal spine is very rudimentary in all the species, and appears only as an appendage of the second. The second anal spine in *T. lepturus* is less developed than in *L. savala* where it is usually a strong, dagger-shaped and more conspicuous in the juveniles. In *E. intermedius* and *E. muticus* the second anal spine is a dorso-ventrally compressed triangular scale rather than a typical spine of the type seen in the other two species. The former also have a great likeness to their rudimentary ventrals which are scale-like.

The soft anal rays are represented by modified spinules which scarcely break through midventrally in *T. lepturus*, but distinctly break through as small curved sharp spines, directed posteriorly in *L. savala*. In *E. intermedius* and *E. muticus*, the external fin is entirely suppressed with the blunt protuberances of the basal elements slightly projecting out along the midventral line of the body in the former, while the ventral profile is very smooth in the latter.

Each radial is represented by the proximal piece or interhaemal spine, consisting of a long vertical proximal limb and a distal short horizontal limb. The horizontal limb articulates firmly with the one preceding and the other succeeding it, so that along the ventral margin of the body is formed a continuous rigid bony support or keel. The basal element is fused with the distal portion of the interhaemal at its middle point. The interhaemals articulate proximally with the corresponding haemal spines. The first interhaemal spine is usually thickened in all the species and is also the largest of the series, to the base of which are attached the two anal spines. There is a gap of one or sometimes none, in the series of interhaemal spines behind the first in *T. lepturus*, *E. intermedius* and *E. muticus* and invariably one or two similar gaps in *L. savala*.

Several interhaemal spines were found to show excessive thickening in individuals of *T. lepturus*, collected from different parts of the Indian coast, as has been discussed elsewhere (James, 1960).

The range in variation of the anal fin elements in the different species is summarised in Table I.

VERTEBRAL COLUMN

The *vertebral column* (Pls. I and II) of the ribbon fishes exhibits a remarkable simplicity when compared to many scombroid fishes.

The vertebrae are more or less short in the anterior region and progressively long posteriorly to tip of the tail. This is specially so in *L. savala*, in which the tail is more filamentous and hair-like, when compared to the other three species. The vertebral column is very long and flexible in these fishes, in conformity with the ribbon-shaped body. But the length of the column is contributed more to by the increased number of vertebrae than by the length of each vertebra. The vertebral column is arched in the course of its length and the arched portion seems to be confined to pre-anal region in *T. lepturus* while it appears to be about midway between anus and tip of tail in the other three species. The bent however, appears more prominent in *E. intermedius*.

The neural and haemal spines are long, slender terminating in sharp points. The spines are stiff and strong in the anterior vertebrae, while posteriorly they become very fine and fragile. The neural and haemal spines are grooved on their anterior and posterior faces. From the anterior end the neural spines gradually increase in height and they decrease in size towards the tip of tail behind the anal point. The anteriormost haemal spines are the longest, and they fall in height towards the tip of tail. The neural arch is shorter and smaller than the haemal, corresponding to the size of canals enclosed. The haemal canal is big in the anterior caudal vertebrae, decreasing in size towards the tail end.

Each vertebra has six longitudinal grooves, ventral median, dorsal median and two pairs of laterals. This feature was also observed in many scombroid fishes (Kishinouye, 1923). The neural pre- and post-zygapophyses are well developed, specially the pre-zygapophyses with which successive vertebrae articulate. The haemal pre- and post-zygapophyses are well developed from the first caudal vertebra onwards. They are only minute processes in the precaudal region and towards the tail end they are reduced.

In all four species, the vertebral column presents a characteristic ridge on either side contributed to by small perpendicular lateral projections or apophyses on each individual vertebra. This lateral ridge appears from the vent or slightly in front of it. Each vertebra from this point bears a sharp, lateral conical projection at its anterior end on either side, with the anterior margin of the lateral process at right angles to the vertebra. The successive processes are clearly separated from one another but appear with wider interspaces at right angles in *Trichiurus* and *Lepturacanthus*, whereas they are closer and inclined anteriorly in *Eupleurogrammus*. At either end the processes are shorter, the highest being about the middle region of their course. About 71 such prominent processes may be counted in *T. lepturus*, 62 in *L. savala*, 82 in *E. intermedius* and 75 in *E. muticus*. The lateral ridges appear more highly developed in *E. intermedius* than in the other three species.

The vertebral number shows both interspecific and intraspecific variation in the species. It may, however, be stated here that due to the extremely fragile nature of the tip of the tail in all the species this region is continually susceptible to breaking and hence there is every possibility that the maximum number of vertebrae in each of the species may be slightly greater than what is stated in the present study. This may be more true in case of *L. savala*, in which, as already noted above, the tail is excessively fragile. To overcome this difficulty, the numbers of vertebrae corresponding to the termination of dorsal and anal fins is given for all species (Table I). In a true end of the tail the urostyle is just a rod-like bone, without the neural or haemal processes. The morphology of the most posterior vertebrae which show interesting differences in the species, is described in greater detail below.

The vertebral column may be divided conveniently into precaudal (abdominal) and caudal portions. The first caudal vertebra is the one with a long haemal spine that articulates with the first interhaemal spine. In all the four species it was found that the range in variation of the number of precaudal vertebrae is less than that in the caudal vertebrae. The details of the variation are presented in Table I. The vertebrae in each of the two regions are more or less uniform in structure, except for minor differences. The first or atlas vertebra is the smallest, anchylosed to the neurocranium and bears ribs. As in many scombroid fishes (Kishinouye, 1923) the neural spines of first few vertebrae are laterally compressed. Such spines are fewer in *Trichiurus* and *Lepturacanthus* than in *Eupleurogrammus*. The rest of the trunk vertebrae bear simple neural spines. The 2nd to the 11th vertebrae in *T. lepturus* bear each a median ridge ventrally, separating the median ventral groove into two lateral halves. A similar partition is seen in the case of *L. savala* from the 2nd to the 8th vertebrae but it divides the groove rather imperfectly. In both *E. intermedius* and *E. muticus* the 2nd to 8th vertebrae exhibit this character, and are similar to those in *L. savala* in the less pronounced nature of their ridges.

The parapophyses make their appearance on the 3rd vertebra, as two small projections on the two sides. They retain the same structure to a considerable length of the vertebral column and suddenly lengthen to form the first haemal arch. The posterior few precaudal vertebrae bear more pronounced paraphyses in *Eupleurogrammus* than in *T. lepturus* and *L. savala*. The relative position of the first closed haemal arch is given in Table I.

The *ribs* in all the four species are very fragile and thin, lining the abdominal cavity, but not forming a complete basket. The more anterior ribs are attached to the centra along their ventro-lateral sides while the posterior ones are articulated in the notch between the haemal pre-zygapophyses and parapophyses of each vertebra at its anterior end. All the ribs are loosely articulated to the vertebrae. The *epipleural ribs* are few, 4-6 in number, present on the first to sixth vartebrae in *T. lepturus*, and the *pleural ribs* appear from 3rd vertebra onwards and extend upto 36-39th vertebra ; in *L. savala* epipleural ribs are 4-5, present on the first to fifth vertebrae, and the pleural ribs appear from the 4th vertebra and extend upto 31-35th vertebra ; in *E. intermedius* epipleural ribs are 3-5, present on the first to fifth vertebra, and the pleural ribs appear from the 3rd vertebra and extend upto 29-32nd vertebra and in *E. muticus* epipleural ribs are 6, present on the first six vertebrae, and the pleural ribs appear from the 1st vertebra extending upto 30-35th vertebra. All the epipleurals are directed dorsally and posteriorly in all the species. The epipleurals are short and stiff in all except in *E. muticus*, where the first two are short, and the last four are very long and stout and more stiff.

In *Trichiurus* and *Lepturacanthus* the ribs are more or less similar extending the full distance of the trunk, while in *Eupleurogrammus* the basket is confined to the anterior end of the trunk with the ribs in this region long and thin while the posterior ribs are strikingly short and blunt.

Morphology of the posteriormost vertebrae : In *T. lepturus* and *L. savala* the most posterior vertebrae have the neural spines and zygapophyses almost reduced (Plate II). This reduction is very great in *L. savalva* when compared to *T. lepturus*. The vertebral column at this region is more in line with the dorsal profile in the former than in the latter. Each vertebra is a simple almost cylindrical rod with a very long, curved, fragile haemal spine, that lends supports to the ventral side of the tip of the tail in *L. savala*, while in *T. Lepturus* the vertebrae are long but dumbel-shaped and distinctly narrower at the mid portion than at either end, the haemal spine being cylindrical, broad at the base and sharp at the tip as in the former.

In *E. intermedius* and *E. muticus* the vertebrae are short, thick and bear distinct neural spines and zygapophyses till the last vertebra (Pl. II). The vertebral column is above the mid lateral line in both *E. intermedius* and *E. muticus*, with the short stumpy neural spines directed posteriorly. The haemal spines are very long and highly curved (more so in *E. intermedius*), with their distal halves laterally compressed (unlike the pointed ends as in *T. lepturus* and *L. savala*). Occasionally a double haemal spine may be present as in *E. muticus* (Pl. II).

The last vertebra in all the species very frequently assumes a bizarre appearance due to extra growths on all sides, much due to the continual loss and rounding off of the tip of the tail (Pl. II).

The dotted line below and parallel to vertebral column in the figures (Pl. II) indicates the course of the lateral line at this region of the body.

RELATIONSHIP BETWEEN THE SUBFAMILIES TRICHIURINAE AND LEPIDOPODINAE

As stated earlier, the four species dealt with in the present paper fall into two natural groups, *T. lepturus* and *L. savala* to the subfamily Trichiurinae, and *E. intermedius* and *E. muticus* to the subfamily Lepidopodinae, in which four other genera are also included. Of these, *Lepidopus* Gouan and *Assurger* Whitley are reported from the Indo-Pacific, while the general *Evoxymetopon* (Poey) Gill and *Tentoriceps* Whitley are so far not reported from this region.

TABLE I

Meristic counts*

No.	Character	*T. lepturus*	*L. savala*	*E. intermedius*	*E. muticus*
1.	Total number of vertebrae ..	13 : 167-175 (170)	12 : 167-187 (177)	12 : 158-163 (160)	12 : 189-201 (192)
2.	Precaudal vertebrae ..	13 : 38-40 (39)	12 : 33-37 (35)	12 : 31-32 (31)	12 : 39-42 (40)
3.	Caudal vertebrae ..	13 : 127-137 (131)	12 : 131-152 (141)	12 : 126-131 (129)	12 : 150-159 (152)
4.	First closed haemal arch at vertebra number ..	13 : 36-39 (38)	16 : 31-36 (33)	11 : 29-32 (30)	11 : 30-35 (33)
5.	Dorsal fin ray count ..	13 : III, 131-136 (132)	14 : IV, 108-123 (116)	12 : III, 123-129 (126)	12 : III, 139-147 (142)
6.	Dorsal extending upto vertebra number ..	13 : 135-140 (136)	14 : 113-128 (121)	12 : 127-132 (130)	12 : 143-151 (146)
7.	Anal fin ray count ..	13 : i+I, 103-109 (105)	14 : i+I, 77-93 (85)	12 : i+I, 113-121 (117)	12 : i+I, 113-122 (116)
8.	Anal extending upto vertebra number ..	13 : 143-148 (144)	14 : 116-130 (122)	12 : 146-153 (149)	11 : 154-163 (158)
9.	Teeth, upper jaw half, main series only ..	8 : 9-14 (11)	24 : 7-15 (10)	25 : 7-12 (10)	8 : 12-25 (19)
10.	Teeth, lower jaw half, main series only ..	8 : 9-14 (10)	24 : 7-15 (10)	25 : 7-12 (10)	8 : 16-23 (19)
11.	Gill rakers, upper limb, main series only ..	8 : 4-8 (6)	24 : 2-5 (4)	25 : 2-8 (5)	8 : 2-6 (4)
12.	Gill rakers, lower limb, main series only ..	8 : 6-13 (8)	24 : 1-8 (6)	25 : 8-15 (11)	8 : 11-16 (14)
13.	Gill rakers, total, main series only ..	8 : 10-21 (14)	24 : 3-13 (10)	25 : 10-23 (17)	8 : 13-22 (19)

*For each character the number of specimens examined is followed by the count, and the mean for each indicated in parentheses. Teeth and gill rakers counted on the left side.

TABLE II

A synopsis of differential characteristics for *T. lepturus*, *L. savala*, *E. intermedius* and *E. muticus*.

No. character	*T. lepturus*	*L. savala*	*E. intermedius*	*E. muticus*
1. Occipital region of neurocranium.	Convex.	Flat. Dorsoventrally compressed	Convex.	Convex.
2. Ethmofrontal crest.	Absent.	Absent.	Absent.	Present.
3. Orbital ring composed of	Three ossicles.	Three ossicles.	One ossicle.	One ossicle.
4. Lacrymal.	Covers only 1/3 length of maxilla and premaxilla.	As in *T. lepturus*.	Covers 2/3 length of maxilla and premaxilla.	As in *E. intermedius*.
5. Orbital cavity.	Huge. About 1/3 length of neurocranium.	Small. Less than 1/3 length of neurocranium.	Less than 1/3 length of neurocranium, situated more towards dorsal profile.	Less than 1/3 length of neurocranium centrally situated.
6. Palatines.	Bear teeth in villiform band.	As in *T. lepturus*.	Bear teeth in irregular linear series.	As in *E. intermedius*..
7. Posterior three branchiostegal rays.	Little longer than the preceding, about ¼ their own length.	As in *T. lepturus*.	Strikingly longer than the preceding, about ½ their own length.	As in *E. intermedius*.
8. Ventral portion of coracoid.	Rod-like.	Rod-like.	Rod-like.	Blade-like.
9. Pelvic girdle and fins.	Absent.	Absent.	Present, fins scale-like.	Present, fins scale-like.
10. Second Anal spine.	Rudimentary.	Dagger-like.	Scale-like.	Scale-like.
11. Posterior few vertebrae.	With reduced or no neural spines.	As in *T. lepturus*.	With prominent neural spines.	As in *E. intermedius*.

Tucker (1956) distinguishes these two subfamilies on the presence or absence of pelvic fins, the disposition of the lateral line and the shape of the hind margin of operculum. The present osteological study on three genera of these two subfamilies shows that the following additional characters also constitute a basis for their differentiation : (1) number of elements constituting the orbital ring, (ii) the relative extent of the lacrymal, (iii) relative length of the posterior three branchiostegal rays and (iv) the structure of the posterior caudal vertebrae. Besides these, it was found that the nature and arrangement of the palatine teeth is very distinct in the two subfamilies, as also the second anal spine.

While these characters constitute differences of some magnitude, the osteology of the other genera of the subfamily Lepidopodinae is expected to differ, especially as the genera show greater diversity. For instance, unlike *Eupleurogrammus*, the genera *Lepidopus*, *Assurger* and *Evoxymetopon* have a distinct caudal fin, which is also absent in *Tentoriceps*.

The osteological features of the members of the subfamily Aphanopodinae are not yet fully studied, as also of the other genera of the subfamily Lepidopodinae. In the light of this study, it is now possible to give a more comprehensive key based on the osteology of the genera and species studied here.

OSTEOLOGICAL KEY

I. Pelvic girdle and fins absent ; orbital ring represented by three elements, the lacrymal, jugal and the dermosphenotic. Lacrymal bone small, covering hardly one-third the length of premaxilla and maxilla. Palatine teeth villiform in a broad band. Inferior margin of suboperculum concave. Second anal spine typically spine-like. Last three branchiostegal rays are very slightly longer (about ¼ their own length) than the preceding. Posterior vertebrae with reduced or no neural spines (Subfamily Trichiurinae).

A. Orbital cavity large, about one-third the length of the neurocranium. Dorsal surface of neurocranium convex and occipital region elevated. Precaudal vertebrae 38-40...*T. lepturus*.

B. Orbital cavity small, less than one-third length of neurocranium. Neurocranium dorsoventrally compressed. Precaudal vertebrae 33-37........*L. savala*.

II. Pelvic girdle and fins present. Orbital ring, represented by one element only, the lacrymal. Lacrymal large, covering two-thirds of premaxilla and maxilla. Palatine teeth small, slightly recurved, arranged in irregular series. Inferior margin of sub-operculum convex. Second anal spine scale-like ; last three branchiostegal rays about half their own length larger than the preceding. Posterior vertebrae with distinct neural spines. (Genus *Eupleurogrammus* of subfamily Lepidopodinae).

A. Precaudal vertebrae 31-32. Median crest on ethmofrontal region absent. Posterior end of maxilla extends to or surpasses vertical below front border of orbital cavity ....*E. intermedius*.

B. Precaudal vertebrae 39-42. Median crest on ethmofrontal region present. Posterior end of maxilla falls short of vertical below front border of orbital cavity ....*E muticus*.

It has also been found that *T. lepturus* and *L. savala* attain bigger sizes than species of *Eupleurogrammus*, the former exceeding even one metre, while the latter has not been reported to exceed 625 mm. (De Beaufort and Chapman, 1951). The author's examination of a large series of samples of these species also indicates the same trend.

RELATIONSHIPS OF THE GENERA OF THE FAMILY TRICHIURIDAE

Regan (1909) allied the Trichiuridae and the Gempylidae to form the first division, Trichiuriformes of his suborder Scombroidei, of the order Percomorphi. His suborder includes three other divisions namely, Scombriformes, Luvariformes and Xiphiformes. However, to have any understanding of the phylogenetic relationships of the genera studied here a reference to osteological work on the various groups indicated above seems necessary. Important contributions to the osteology of the true Scombroid fishes have been made by Allis (1903), De Sylva (1955), Gregory (1933), Gunther (1860), Kishinouye (1923), Leccia (1956), Starks (1910, 1911) and others.

Regan's definition of the division Trichiuriformes includes the following osteological features ' caudal fin rays not deeply forked at the base, the hypural in great part exposed. Premaxillaries beak like, free from the nasals. Epiotics separated by supraoccipital. In his generalised definition of the family Trichiuridae, attention is drawn to several important osteological characters which the author is able to corraborate with slight modifications. These are as follows :—

(i) ' Maxillary sheathed by the preorbital.' The preorbital or lacrymal covers not only a part of maxillary (maxilla) but also the premaxilla in *T. lepturus*, *L. savala* and *Eupleurogrammus*.

(ii) ' Anal with numerous short spines.' The anal rays are represented by reduced spinules, more prominent in *L. savala* than in *T. lepturus*. In *E. intermedius* the basal elements can still be noticed as blunt protuberances along the mid-ventral line of the body, while the ventral profile is very smooth in *E. muticus*.

(iii) ' Pelvic fins reduced to a pair of scale-like appendages or absent.' The pelvic fins consist each only of a scale-like spine in *Eupleurogrammus*.

(iv) ' Dorsal and anal rays corresponding to the vertebrae, each interneural or interhaemal attached to a neural or haemal spine.' Usually the dorsal rays and their basals and interneurals always correspond to the trunk vertebrae. A similar condition is also seen for dorsal and anal rays in the caudal region but for occasional irregularities, such as three interhaemals with basal elements being related to a single vertebra ; two interhaemals articulating with a single basal element ; a haemal spine lacking an interhaemal, its basal element remaining free ; and two interneurals and two interhaemals articulating with a single vertebra with double neural and haemal spines. These irregularities are seen in all the four species, and appear to be common on the haemal than neural side. Since their occurrence is sporadic, it is likely that they represent a teratological condition.

(v) ' Pelvic bones, if present, united to form a slender spicular bone connected with the cleithra by a ligament.' The pelvic bones form a fused fenestrated structure, elongated in *Eupleurogrammus*.

(vi) 'Vertebrae numerous 100 (43+57) to 159 (39+120) or more.' Vertebral counts are much higher than hitherto noticed, details of which are presented in Table I.

In addition to these, the osteological characters of the family Trichiuridae have been studied for the following forms, genus *Aphanopus* by Gunther (1860), genus *Lepidopus* by Gregory (1933) and Starks (1911). On the basis of this, as well as the present study, it is possible to draw up a Table showing the common and differential osteological characters of the genera hitherto studied, thereby drawing attention to their affinities.

The close affinity between various members of the family Trichiuridae was drawn attention to in the above table. However, in the last five characters, very interesting differences are seen from genus to genus while at the same time, some which are otherwise distinct, show similarities. The phylogenetic tree presented by Tucker (p. 126), appears to represent this trend well for the different genera studied here. However, on the basis of the present study it is also possible to add that the differences between *T. lepturus* and *L. savala* are relatively smaller than those between the two species of *Eupleurogrammus*, *E. intermedius* showing convergence towards the condition seen in *Trichiurus*. Preliminary investigations on the food and feeding habits of these fishes indicate that *E. intermedius*, like *Trichiurus* is a more predaceous form when compared to *E. muticus*. In *L. savala* this trend is seen to attain the maximum development while *E. muticus* shows least specialisation in this direction. Perhaps this functional divergence has been responsible for bringing out wider differences between the two species of *Eupleurogrammus*, as *E. muticus* appears to subsist on smaller organisms of the same type.

SUMMARY

Comparative osteology of the four Indian species of ribbon fishes, *Trichiurus lepturus*, *Lepturacanthus savala*, *Eupleurogrammus intermedius* and *Eupleurogrammus muticus* is described.

The elongation of the bones, specially those of the preorbital region of the skull in all the four species illustrates the extremely predaceous habits of the members of this family. The preorbital region of the skull of *L. savala* shows a maximum elongation, and that of *E. muticus* minimum. This feature and the arrangement of teeth and gill rakers indicates *L. savala* as extremely carnivorous and *E. muticus* less predaceous of the four species. This view is corroborated by the studies on food of these fishes, to be published elsewhere.

The study, while substantiates the affinity between them, draws a distinction between two groups, one represented by *T. lepturus* and *L. savala* and the other by *Eupleurogrammus*. The basic skull pattern in the four species is comparable to other genera of the family.

The convergence or divergence between the four species, as evidenced by the structure of the skull and other parts of the skeleton may be explained as a result of function.

TABLE III

Character	*Aphanopus*	*Lepidopus*	*Eupleurogrammus*	*Lepturacanthus*	*Trichiurus*
1. Preorbital portion of skull..	Elongated	Elongated	Elongated	Elongated	Elongated
2. Longitudinal grooves and ridges on the skull ..	Present	Present	Present	Present	Present
3. Occipital crest ...	Low	Low	Low	Low	Low
4. Operculum and suboperculum ..	Fringed	Fringed	Fringed	Fringed	Fringed
5. Vomerine teeth ..	Absent	Absent	Absent	Absent	Absent
6. Lacrymal ..	Covers the space between orbit and jaw bones	Covers the space between orbit and jaw bones	Covers the space between orbit and jaw bones	Covers the space between orbit and jaw bones	Covers the space between orbit and jaw bones
7. Vertebrae ..	Numerous	Numerous	Numerous	Numerous	Numerous
8. Canine-like teeth ..	Slightly barbed	Slightly barbed	Slightly barbed	Slightly barbed	Slightly barbed

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LIST OF ABBREVIATIONS

alsp., alisphenoid ; an., angular ; art., articular ; bb_1-bb_3., basibranchials 1-3 ; boc., basioccipital ; brstg., branchiostegal ray ; bshy., basihyal ; bshp., basisphenoid ; cb_1-cb_5., ceratobranchials 1-5 ; cerhy., ceratohyal ; clt., cleithrum ; cor., coracoid ;* ct., cartilage ; deth., dermethmoid ; dn., dentary ; dsph., dermosphenotic ; eb_1-eb_4., epibranchials 1-4 ; * efrc., ethmofrontal crest ; enpt., entopterygoid ; ephy., epihyal ; epiot., epiotic ; exo., exoccipital ; fr., frontal ; glass., glassohyal ; hb_1-hb_3., hypobranchials 1-3 ; hyom., hyomandibular ; ihy., interhyal ; iop. interopercle ; ju., jugal ; la., lacrymal ; mtp. metapterygoid ; mx., maxilla ; na., nasal ; op., opercle ; opo., opisthotic ; pa., parietal; pas., parasphenoid ; pb_1-pb_4., pharyngobranchials 1-4 ; pcl., postcleithrum ; pelv., pelvis; pf., prefrontal ; pfr., pectoral fin ray ; pl., palatine ; pmx., premaxilla ; pop., preopercle ; proot., prootic ; psp., pectoral spine ; ptm., post-temporal ; pto., pterotic ; ptopr., pterotic process ; ptr., ectopterygoid ; ptryg., pterygial ; pvf., pelvic fin ; qu., quadrate ; scap., scapula ; soc., supraoccipital ; sop., subopercle ; sphot., sphenotic ; supcl., supracleithrum ; sym., symplecitic ; urohy., urohyal ; vo., vomer.

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*New abbreviations.

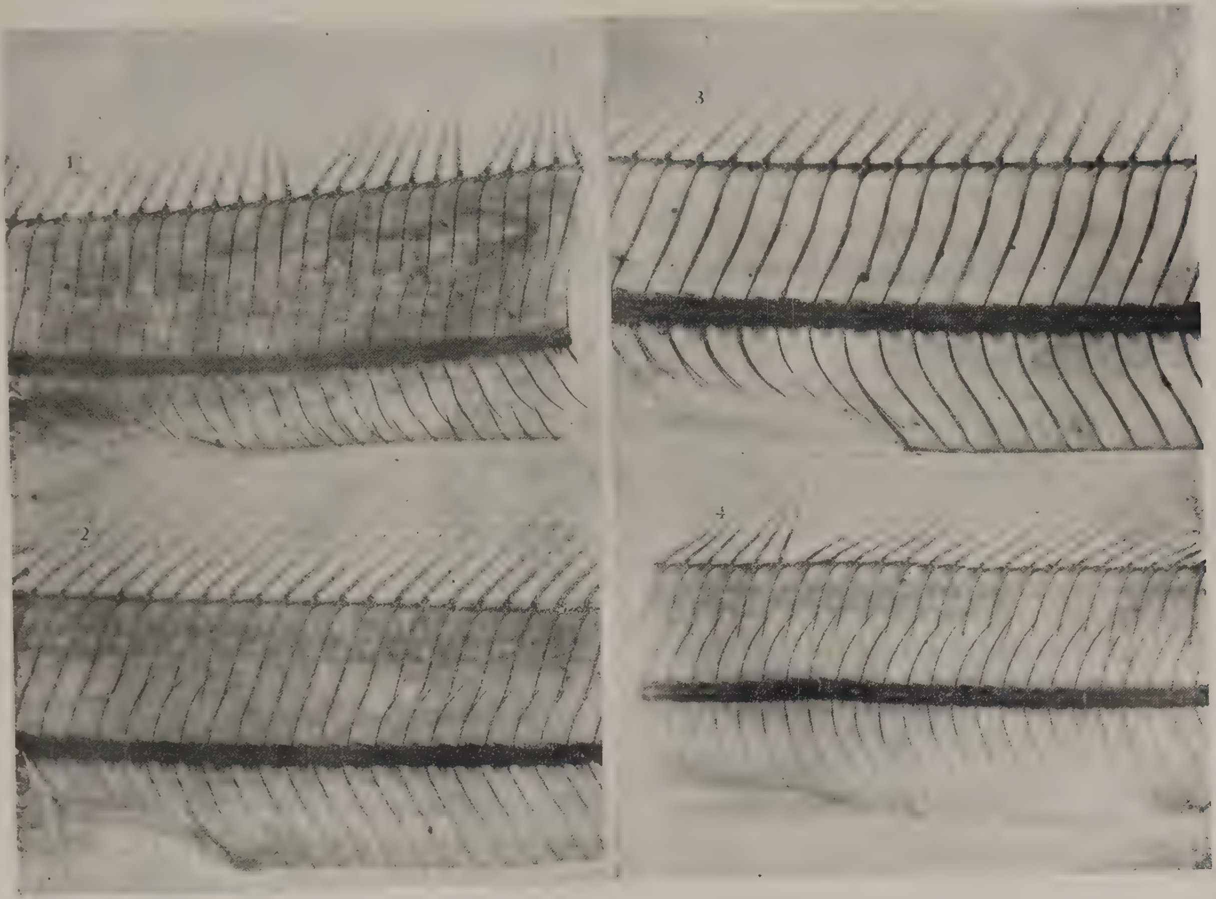

Plate I. Comparative osteology of anal region, showing dorsal and anal fins and vertebral column (alizarin stained). 1. *T. lepturus* (S.L., 32.5 ; S.V., 10.8 cm.). 2. *L. savala* (S.L., 37.1 ; S-V. 11.8 em.). 3. *E. intermedius* (S. L., 45.7 ; S-V., 14.0 cm.). 4. *E. muticus* (S.L., 42.9 ; S-V. 11.9 cm.)

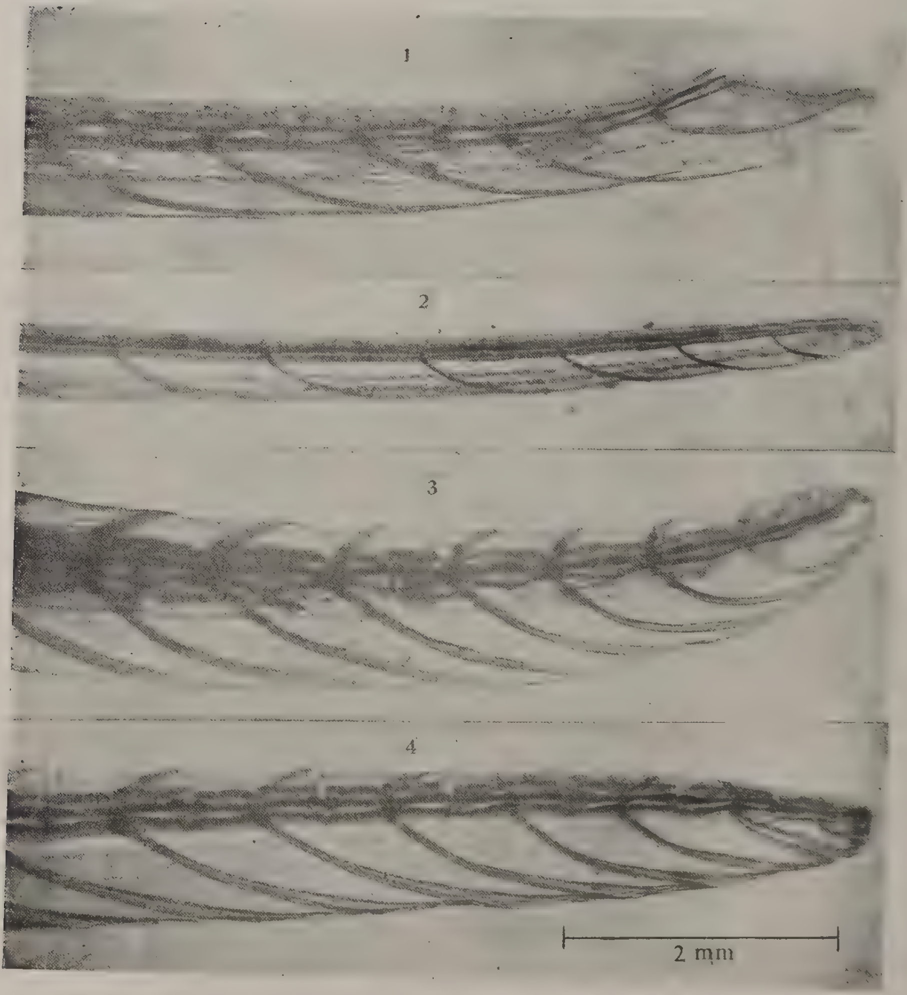

Plate II. Photomicrographs of posterior vertebrae (alizarin stained.) 1. *T. lepturus.* 2. *L. savala.* 3. *E. intermedius.* 4. *E. muticus.*

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MARINE BIOLOGICAL AND OCEANOGRAPHIC INSTITUTIONS OF THE WORLD

V. THE PORT ERIN MARINE BIOLOGICAL STATION OF THE UNIVERSITY OF LIVERPOOL

By John S. Colman

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The Marine Biological Station of the University of Liverpool is situated at Port Erin, Isle of Man, in the Irish Sea ; it is roughly equidistant from England, Scotland, Ireland and Wales.

The origins of the Station go back to 1886, when the Liverpool Marine Biological Committee opened a small laboratory on Puffin Island off Anglesey. After five years on Puffin Island, activities were transferred to Port Erin in 1891, and to the present building in 1902. For the first forty years the leader and guiding spirit was Professor Sir William Herdman, until in 1923 the administration of the biological station was transferred to the University of Liverpool, of which it has constituted a separate department since 1950. The buildings have been enlarged and improved during the past decade ; they contain a good, if small, library (with, of course, the full resources of the University library behind it), a dark-room, research rooms and laboratories, a fish hatchery, a workshop, two large students' laboratories and a public aquarium. The whole building is piped for sea water, which is delivered by gravity from a 20,000 gallon storage tank ; water is pumped every day into the latter from the sea nearby. There are also three sea water ponds in which stocks of breeding fish can be maintained.

For outside work there are three vessels :—the rowing-boat *Metanauplius* for working seine-nets and so on inside the Bay, the 30-foot motor boat *Cypris* for dredging, tow-netting and diving inshore, and, for most of the year, the 60-foot motor vessel *William Herdman* which can accommodate ten people and go anywhere in the Irish Sea.

There are seven people (including two phycologists) on the research staff, and usually five resident research students ; several visiting research workers also come each year to work at Port Erin. The two large students' laboratories are energetically used by many classes from universities and schools throughout England and Wales, who come, numbering with their teachers about 450 a year, on intensive vacation courses lasting about a week each. The public aquarium is kept well stocked with local fish and invertebrates, and is visited annually by some 40,000 people.

Port Erin is very well placed for work on marine biology. Depths down to 100 metres are easily accessible, and the sea-bed varies (as do the associated floras and faunas) from rock through gravel and shell-gravel to sand and mud. The shore, too, includes rocks of many shapes and exposures, sandy and muddy beaches, and a useful little estuary at Castle town nearby. The water inshore in unusually clear for Britain, and is being increasingly exploited by means of the aqualung, even throughout the winter when the temperature of the sea is less than 7°C.

Among the lines of research work now being pursued there can be included : the scallop and herring fisheries ; plaice-rearing under controlled conditions ; the biology of small fish and several groups of invertebrates ; the parasites of fish ; the underwater distribution of seaweeds ; the taxonomy and life histories of seaweeds ; the behaviour of plankton ; the plankton, chemistry and water-movements of the Irish Sea.

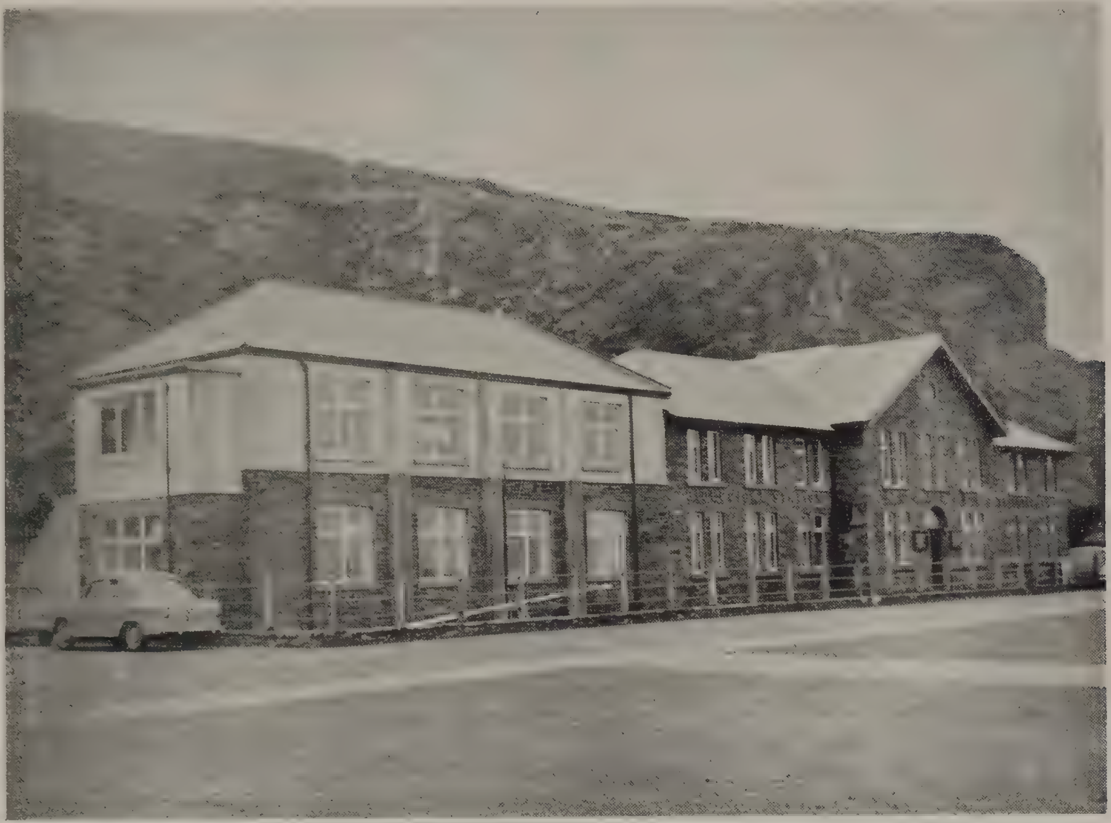

Fig. 1. Marine Biological Station, Port Erin ; General View. To the left, students' laboratories (ground floor 1932, top floor 1960). To the right, main building (1902) with research rooms and entrance to the aquarium.

(*By courtesy of the Isle of Man TIMES*)

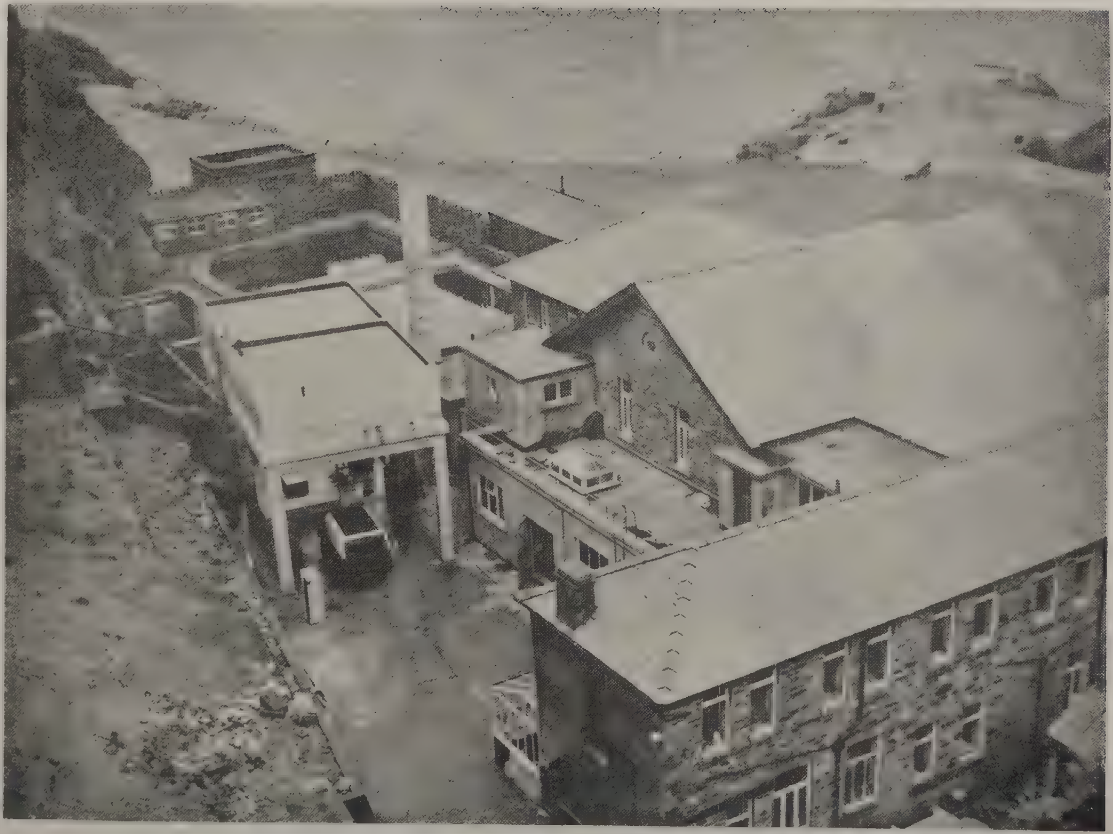

FIG. 2. Marine Biological Station, Port Erin; view of rear from cliff, showing sea water storage tank with fish ponds beyond. The library is beneath the skylight in the main roof. *(By courtesy of the Isle of Man TIMES)*

NOTES

A NOTE ON THE OCCURRENCE OF THE ANTHOMEDUSA *CLADONEMA* IN THE INDIAN REGION

On 30-3-1961 while cleaning one of the experimental aquaria, which was partly filled with sea water and not used for nearly three weeks, the occurrence of a large number of small medusae was observed. These were readily identified as the anthomedusa, *Cladonema* Dujardin. The identification of the species, however, has been more difficult because of slight variations in some of the characters from the available descriptions of the different species. After a critical study and comparison

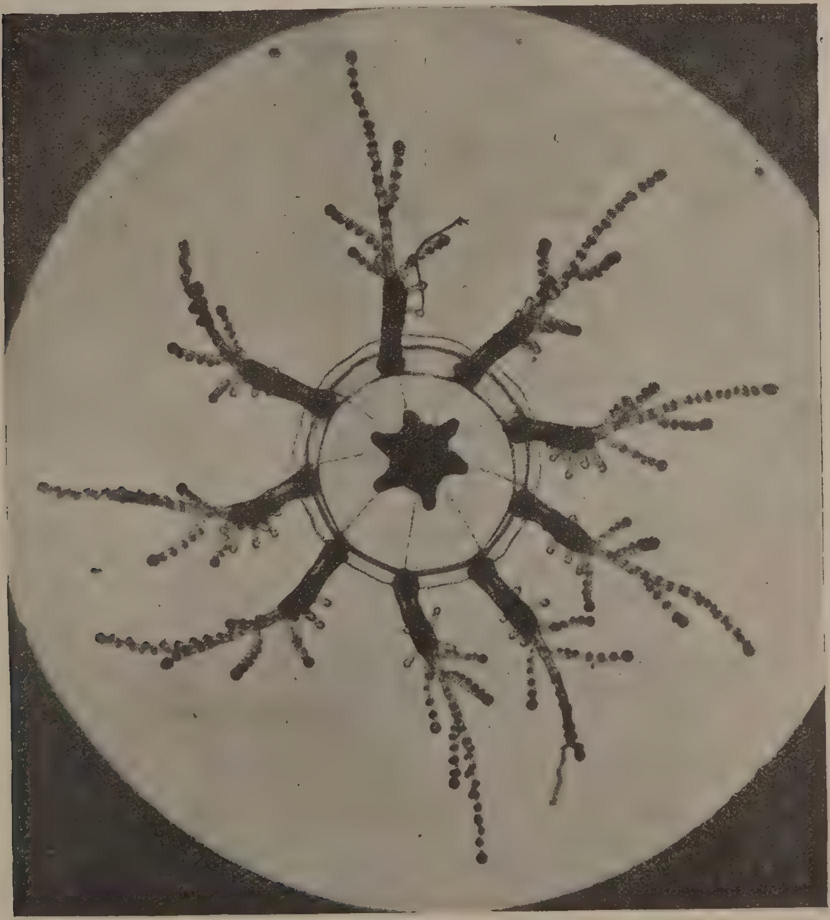

FIG. 1. *Cladonema radiatum* var. *mayeri*. (× 12)

of the specific characters of the present species with those already described, it became evident that the species obtained by us is *Cladonema radiatum* var. *mayeri* (Fig. 1). The species *mayeri* was originally described from Florida (see Kramp, 1928) but the present tendency is to regard the species as only a variety of *C. radiatum* (Russell, 1953). Prof. P. L. Kramp in a personal communication to one of us (R.R.P.) also agrees with the earlier authors who consider *C. mayeri* as a variety of *C. radiatum.* Except for some minor differences in a few specimens the present ones agree with the description given by Mayer (1910) for *C. mayeri.* The variations noticed are in the number of adhesive organs at the base of the marginal tentacles which goes up to 7 instead of the usual 6, and in the arrangement of the radial canals where 5 unbranched and two bifurcating ones make up the total of 9 as against 6 canals, every alternate one bifurcating. These characters are subject to variation (see Russell ,1953) and on account of the extreme variability of the species these are considered to be of no special significance.

Hitherto no species of *Cladonema* has been recorded from Indian waters. In the eastern hemisphere *C. radiatum* var. *mayeri* has so far been recorded only from Japan (Uchida, 1927 and Kramp, 1928) and from China (Chow and Huang, 1958). Since the record from China the species has not been reported from any other locality and as such the present finding is interesting.

Russell (1953) has remarked that the hydroid and the medusae of *C. radiatum* turn up occasionally in aquaria, having been found at the Zoological Gardens and the University College, London, and has discussed the habits of the medusa. In the sea the medusa is believed to live amongst seaweeds. The hydroid form of the species is a slender, simple or slightly branched colony of about 25 mm. in height. The hydroids must have been growing in the aquarium and would have escaped our notice when we first discovered the medusae in the tank. It is now certain that the species occurs in our waters and a careful search will reveal the presence of this at other places along the coast of India.

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ON TWO OPISTHOBRANCHIATE MOLLUSCS, *PLACOBRANCHUS OCELLATUS* HASSELT AND *DISCODORIS BOHOLIENSIS* BERGH, FROM INDIAN WATERS NOT HITHERTO BEEN RECORDED

Placobranchus ocellatus Hasselt 1824.—In the month of July 1960 a small sea slug from among the sea weeds found on dead coral in the shallow water region of the Palk Bay in front of the fish farm was collected by Dr. S. Jones. Subsequently in October 1960 two more numbers of this form were obtained by him from the same locality. These were later identified as *Placobranchus ocellatus* van Hasselt under Family Elysiidae and Order Sacoglossa (Thiele 1931*a*).

The largest of the forms measured 3.8 cm. in length. The body is leaf-like and the lateral extensions of the mantle in the usual creeping position are folded upon the back, the edges of the opposite sides meeting along the mid-dorso-median line with the result that the morphological dorsal surface of the body is not exposed but completely hidden from view. The head is flat, broad and almost squarish in appearance with a pair of rhinophores which are thin and folded lengthwise upon themselves. The eyes are situated very close to each other in association with the nerve ganglia and are visible through the semi-transparent skin covering the head. When the lateral expansions are lifted up the dorsal surface of the body reveals a number of branchial ridges running lengthwise. Just behind the region of the head is a small bulging which marks the position of the crop lying within. The foot is long and broad and not distinctly demarcated from the lateral mantle folds. The mouth is terminal, anterior and median in position in the region of the head (Text Fig. 1 *a* and *b*).

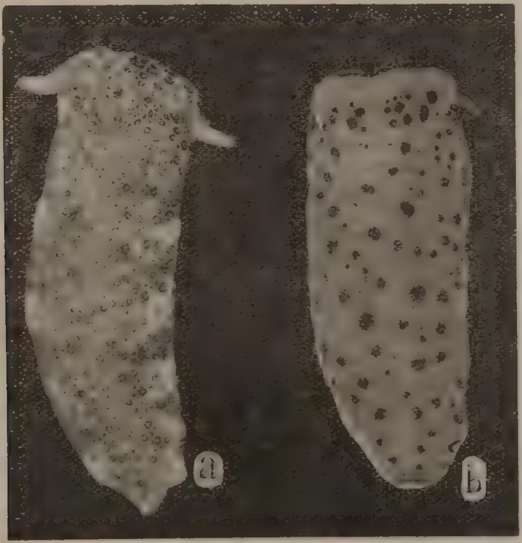

FIG. 1(*a*) *Placobranchus ocellatus* Hasselt, dorsal view x 2 ; (*b*) *P. ocellatus*, ventral view x 2.

The ventral surface of the head and of the foot bears dark spots. The dorsal region of the head and the exposed surface of the mantle folds also present numerous close set dark, small and large markings most of which when magnified, appear as distinct rings. The entire foot region and the head are grayish white. On the surface of the mantle on either side are 4 to 5 areas where the colouration is light yellow. The spots on the foot and the mantle are black. The ring-like markings also are generally black but the larger ones, particularly those at sides, are tinged with violet. The inside of the folded rhinophores is of a pinkish or of a violet hue.

The radula presents the same general structure as in other members of the Sacoglossa. In *P. ocellatus* examined by me there were about 8 teeth in the ascending series, the same number in the descending series and nearly 40 worn out ones in the sac or ascus. The anterior half of each tooth had 10 denticles on either side (Text Fig. 2 *e* and *f*). In the specimen described by Eliot (1903) the marginal denticles on the teeth were about 12. *P. argus* Bergh from the Philippine region appears to be synonymous with *P. ocellatus* (Eliot 1903). *P. priapinus* Bergh (1872 and 1905*a*) seems to be distinct from *P. ocellatus* particularly in regard to its characteristic green colouration.

The species is now known to occur in the East African, Indian, Philippine and Australian waters.

Discodoris boholiensis Bergh, 1877.—Two specimens of this species belonging to Nudibranchiate Gastropoda under the family Dorididae and sub-family Discodoridinae (Thiele 1931*b*) were obtained in the month of January 1961. One of these was of a medium size, measuring 4 cm. by 3 cm. from the Marine Bay, Port Blair, Andaman Islands and the other fairly large being 7.5 cm. by 5 cm. from the Gulf of Mannar near the Central Marine Fisheries Research Institute, Mandapam Camp.

In general the species has a widely spread out mantle which is roughly oval in outline in the living animal when it remains undisturbed. In the preserved specimens the borders of the mantle and the foot present usually an undulated appearance. The mid-dorsal region between the rhinophores and branchiae is closely mottled brown and prominently elevated lengthwise. The rhinophores are dark brown and are retractile into sheaths, the margins of which are wavy and of the same colouration. The branchiae arise from a pocket-like space the opening of which appears as a transverse slit (Text Fig. 2 *a*, *b* and *c*).

The dorsal edge of the mantle in the larger form is dark brown as described by Eliot (1903) and that of the smaller one has a row of deep brownish spots as shown in Fig. 9, Tafel I given by Bergh (1905*b*). The branchiae are six in number of which the posterior two are bifid. They are deep dark brown or almost black. The foot is oval in appearance and is much narrower than the mantle. Its margin all round is lined deep dark brown like the edge of the mantle. In regions other than those mentioned above, the general colour of the mantle, the sides of the body and the foot is pale yellow. The dorsal surface bears small papillae, some of which are pale yellow and others dark brown.

The labial cuticle has two plates formed of numerous small rod-like bodies. The radular structure with hamate teeth (Text Fig. 2 *d*) is the same as in the earlier accounts given by Bergh (1905*b*) and Eliot (1903).

Bergh reported the species from the Philippine region, northern and southern regions of Celebes and the nearby islands. Eliot's account deals with a form obtained from Zanzibar on the east coast of Africa. With the present new record of its occur-

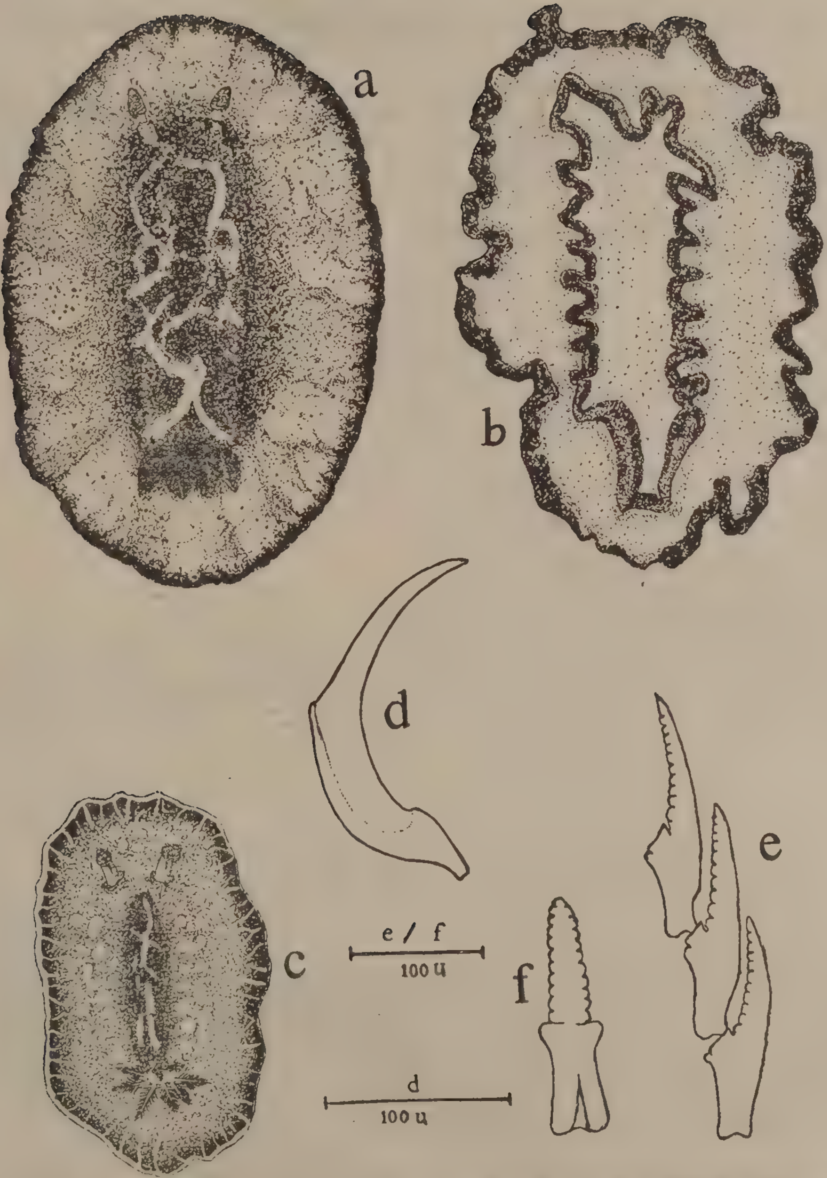

FIG. 2(*a*) *Discodoris boholiensis* Bergh, adult specimen from the Gulf of mannar, dorsal view x 1 ; (*b*) *D.boholiensis*, same as above when preserved, ventral view x 1 ; (*c*) *D.boholiensis*, smaller individual from Andamans (Fig. after Bergh, *Siboga Expedite*, 1905) x 1 ; (*d*) *D.boholiensis*, single tooth of the radula from the Andaman specimen ; (*e*) *Placobranchus ocellatus*, three teeth of the radula as in lateral view ; (*f*) *P.ocellatus*, view of a single tooth showing denticles on either side.

rence in the Gulf of Mannar and the Andaman Islands, it may be concluded that the species is distributed throughout the Indo-Pacific region.

I offer my very sincere thanks to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for making available the specimens of *Placobranchus ocellatus* which he himself had collected and for the interest he had shown in the presentation of this paper. I am also thankful to Shri K. G. Nambiar of the Research Institute for taking photographs of the specimens described here.

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EXTERNAL MORPHOLOGY AND EARLY DEVELOPMENT OF *PLEUROBRANCHUS* (*OSCANIUS*) SP. FROM GULF OF MANNAR

IN a dredge collection from the Gulf of Mannar at one and a half fathoms depth near the Central Marine Fisheries Research Institute at Mandapam Camp four numbers of a species of sea-slug under the genus *Pleurobranchus* Cuvier and subgenus *Oscanius* (Leach) (*vide* Thiele 1931) along with their egg ribbons were obtained on 25th December, 1960. To the best of our knowledge the form obtained has not so far been described, although Bergh (1905) in his Report on Opisthobranchiata of Siboga Expedition in Tafel II, Fig. 2, gives an almost identical form as *Oscanius* sp. Unfortunately the original specimen of the Siboga Expedition as also the notes thereof were lost as stated under the legend to the figure referred to above.

The largest specimen in the collection measured 12 cm. long, 8 cm. wide and 3.5 cm. high. It has an ample mantle extending as a thin fold on either side and also on the posterior region of the body (Plate I, Fig. A, B & C). Anteriorly the extension of the mantle is comparatively narrower and also notched in the middle above the head wherefrom a pair of moderately long soft tentacles arises. The foot, like the

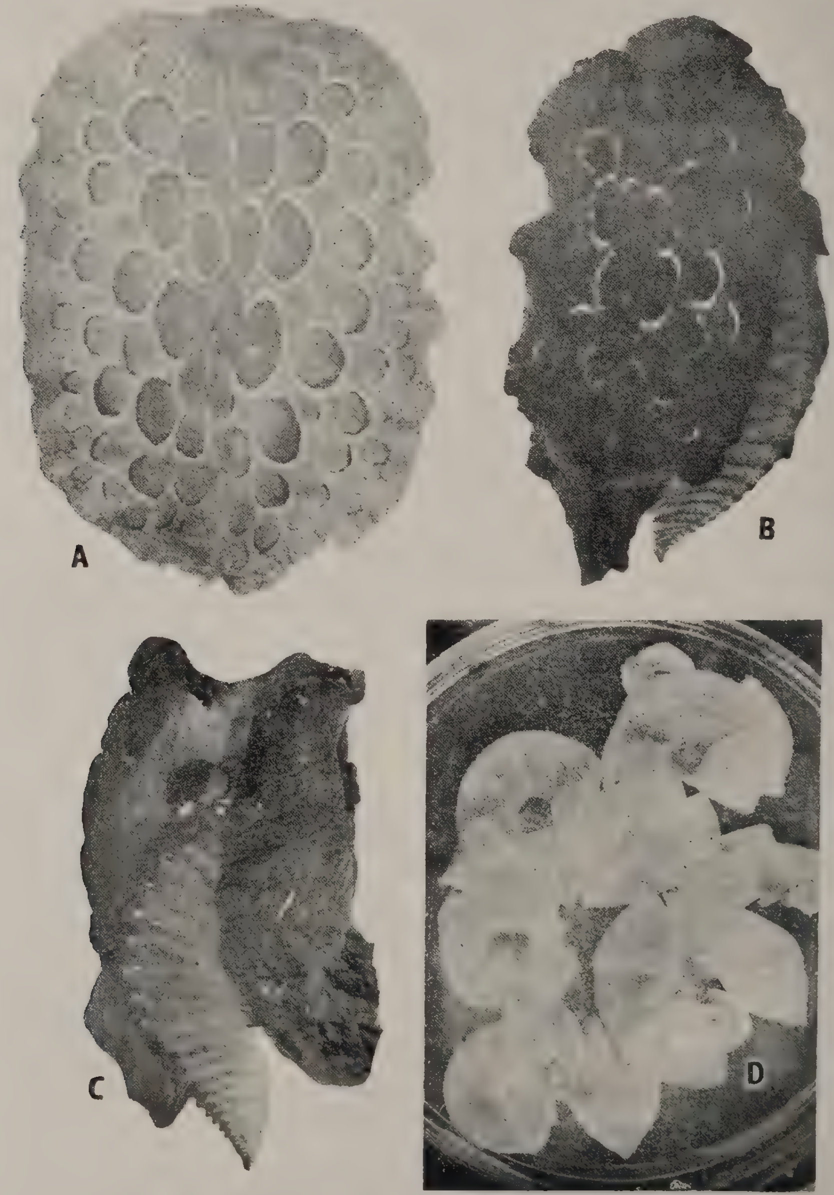

PLATE I. *Pleurobranchus* (*Oscanius*) sp. A. Dorsal view of lightly coloured specimen $\times \frac{2}{3}$. B. Dorsal view of darkly coloured specimen showing also the ctenidium. $\times \frac{2}{3}$. C. Side view of the animal showing the mantle, foot and the ctenidium. $\times \frac{2}{3}$. D. Freshly laid spawn. $\times \frac{3}{5}$.

mantle, is large. It is flat and more or less oval. At the mid-posterior region on its surface, when viewed ventrally, there is an oval patch of a lighter colouration than the surrounding region denoting the position of the pedal gland as in other members of the genus. About one-third the length of the body from the anterior end the ctenidium arises on the right side close behind the genital orifices (Plate I, Fig. C). Posteriorly it extends slightly behind the region of the mantle.

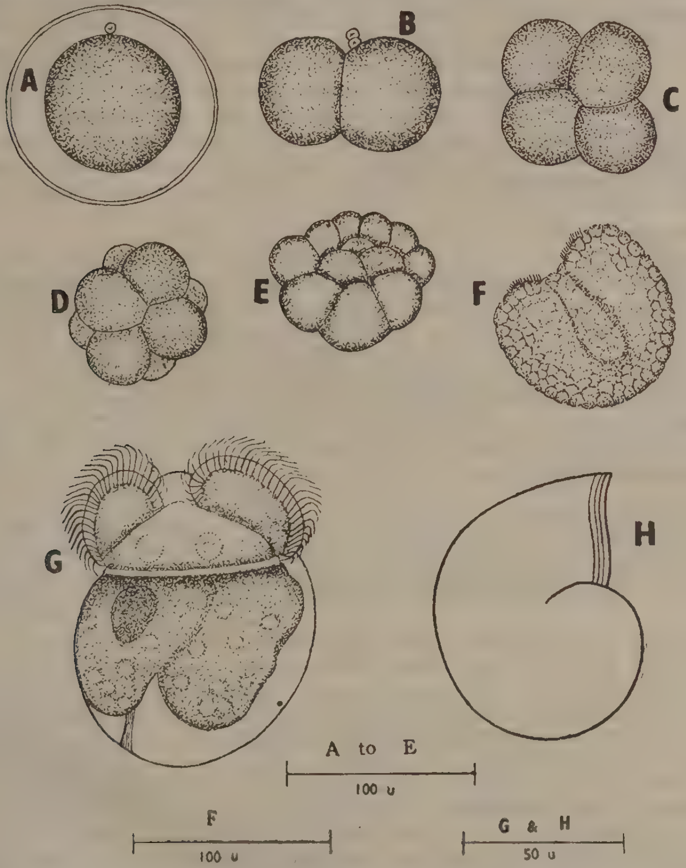

FIG. 1. Early developmental stages of *Pleurobranchus* (*Oscanius*) sp.
A. Egg enclosed in the capsule before cleavage. B. Two-cell stage. C. Four-cell stage. D. Eight-cell stage. E. Formation of blastula. F. Gastrula. G. Veliger. H. Larval shell.

The mantle presents dorsally a finely tuberculated and tessellated appearance and bears a number of close set conspicuous oval or roundish markings. These are very large and mostly oval in the middle region and much smaller and circular in outline on the periphery of the mantle. Each of these markings, particularly the larger ones, has for its border a darker hue immediately followed by a whitish or light yellowish region like a halo. The markings on the mantle described here appear to be very characteristic of the species and they are exactly similar to the ones noticeable in the figure given by Bergh (1905).

The general colouration of the dorsal surface of the mantle, ctenidium and the foot appears to vary widely in different individuals. Of the four specimens in the collection the ground colour in two was yellowish brown, in one it was of a deep pinkish hue and in the fourth a combination of yellow, brown and pink. The under surface of the mantle and the sides of the body are more or less pale white. The animal appears to change its ground colour possibly in relation to change in environment. The colouration along the border of the markings is invariably of a darker hue as stated above ranging from deep brown to greyish black. The ground colour of the original form as shown in Bergh's figure is deep orange yellow. The foot in the mid-posterior region is shown in his figure as having a deep cleft. If the present form is identical with the one figured by Bergh the cleft shown by him in the foot is possibly a mutilation which is not found in the specimens examined by us.

Embedded in the skin are numerous rod-shaped spicules.

The freshly laid spawn (Plate I, Fig. D) attached to the weeds and obtained in the dredge along with the adult specimens was gelatinous, ribbon-shaped and spirally twisted with the different whorls resting on the same plane. The largest of the spawn measured about 40 cm. long, 4 cm. wide and 2 mm. thick. The edges of the ribbon were parallel to each other while its surface within the whorls had undulations presenting a flower-like appearance when found on weeds and remaining in water undisturbed. On close examination, each ribbon revealed a large number of minute eggs arranged in parallel oblique rows. They were over a million in number in a moderately long ribbon.

As the entire ribbon being large, was found unwieldy for tracing the developmental stages, strips about a cm. long were separated from it and placed in finger-bowls containing aerated sea water which was frequently changed. Smaller bits of these pieces were carefully removed at intervals to study the course of development.

The eggs were spherical, whitish and laden with yolk, each measuring 75 μ in diameter and enclosed in a separate double-walled transparent capsule of 120 μ in diameter (Fig. 1, A). The space between the egg and the capsular membrane is filled with a transparent, colourless, albuminous fluid as in other species of Opisthobranchs. At first when the eggs were examined they did not show any cleavage but they had extruded one or two polar bodies. About 3 hours later the first cleavage took place in a vertical plane dividing the egg into two equal halves (Fig. 1, B). This was followed by a second cleavage in the same plane resulting in four cells (Fig. 1, C). In about six and a quarter hours after the extrusion of the polar bodies a stage had reached with four large and four other small cells (Fig. 1, D). Subsequent cleavages took place in rapid succession and in about twelve hours the embryo reached the blastula stage. This was followed by gastrulation which was completed by about twenty-nine hours. The gastrula (Fig. 1, F) with finely developed cilia began to rotate within the capsule and measured 85 μ across. Further development lead to the formation of the veliger with a conspicuous shell enclosing the soft body with prominent velar lobes, foot, digestive, excretory and sensory organs (Fig. 1, G). Close beneath the foot was seen the operculum. A pair of statocysts with a single statolith in each was clearly visible beneath the region of the velar lobes through the transparent tissues. The mouth, oesophagus, stomach and intestine were well developed. The liver lobes were prominent. There was a pink coloured excretory organ towards the anterior right region, on account of which the entire ribbon with the developing embryo inside at this stage had assumed a pale pink colouration. Thorson (1946) observed in *Philine scabra* Muller a similar excretory organ, carmine in embryos and jet black in the pelagic larvae. In general, most of the tectibranch larvae in their free swimming stages possess a large black excretory organ. Several hours later the veligers were liberated from the capsule but they were without eyes. They measured each 105 μ along the long axis and their shells presented near the aperture a few parallel striations (Fig. 1, H). Further stages could not be obtained as they were quickly attacked by ciliates.

A detailed systematic study of the present form is being attempted.

Our sincere thanks are due to Dr. S. Jones, Director, for the keen interest he has shown in the preparation of this note, to Shri S. Mahadevan who collected the materials and for having placed them at our disposal and to Shri P. R. S. Tampi of the Central Marine Fisheries Research Institute for taking the photographs.

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THE PEARL WING SHELL, *PTERIA PENGUIN* (RÖDING) FROM THE ANDAMAN ISLANDS, INDIA

During a recent visit to the Andaman Islands in January-February, 1961, the writer obtained two pearl wing shells which were collected by a diver in the waters of about six fathoms depth in the vicinity of the Havelock Island in Ritchie's Archipelago. As these shells are hitherto very little known from the Indian waters, in the following account their conchological characters are described with notes on the taxonomy and distribution of *Pteria penguin* (Röding) to which they have been ascribed under the family Pteriidae of Bivalvia. The shells from the aforesaid locality have also been compared with those of the same species from the pearl paars of the Gulf of Mannar.

The shells from the Andaman Islands are inequivalve, the left valve in each being larger and deeper than the right valve which fits over the former like a lid. The hinge is fairly long and straight, the anterior and posterior auricles are well developed and the longest axis of the body of the shell is directed backwards forming an acute angle with the hinge line from the umbonal region. The outer surface of the valves is scaly with the periostracal layer coloured black. It was tinged green when the animals were collected fresh. Oysters barnacles and some calcareous algae were found profusely infesting the shells. The internal surface of the valves is lined by a silvery white nacreous layer with a black non-nacreous border, which is wide in the mid-postero-ventral margin of each valve but gradually becomes narrower in front and behind. In the region of the anterior and posterior auricles the non-nacreous border is extremely narrow. The nacreous region is a little copper coloured along the border and it spreads over to a greater extent in the left valve than in the right valve. The anterior auricle is well developed and more or less triangular in shape, whilst the posterior auricle though equally well formed is narrow. There is a clear impression of the adductor muscle in the mid-postero-dorsal region of each valve. The shells are found attached by strong byssus to dead coral.

The inner views of both the valves of the two shells in Fig. 1 (A & B) and their linear measurements are given in Table 1. As could be seen from them both the auricles, proportionately to the long axis of the body, are of greater size in the smaller shell than in the larger one. Apparently in these shells as growth takes place there is a greater increase along the long axis of the body than along the axis on the hinge line.

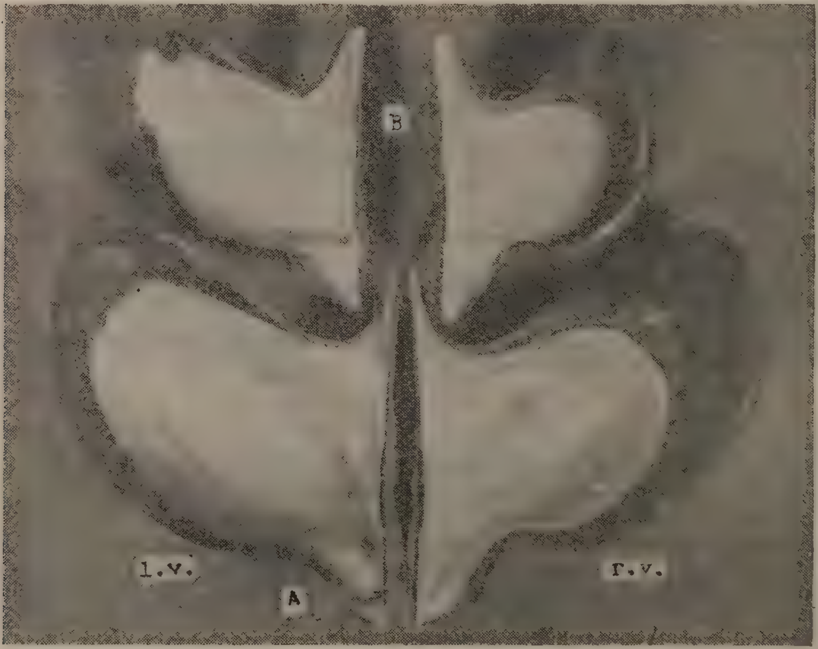

Fig. 1. *Pteria penguin* (Röding). A & B, specimens 1 and 2 : *l.v.*, left valves ; *r.v.*, right valves.

The genus *Pteria* Scopoli 1777, according to Jameson (1901) is divisible into three sub-genera viz., (1) *Pteria* s.s. in which the hinge is large, the anterior and posterior auricles are well developed and the longest axis of the body of the shell is directed backwards at an acute angle from the hinge line, (2) *Margaritifera* (Synonymous with *Pinctada* Röding, *vide* Prashad and Bhaduri, 1933) where the hinge is of moderate length, the anterior auricle is well formed, the posterior auricle when present is poorly developed and the longest body axis is at right angles to the hinge line and (3) *Electroma* Stoliczka in which the hinge is short, the posterior auricle absent and the longest axis is as in *Pteria* s.s. directed backwards. It may be seen that the shells described here are referable to the subgenus *Pteria* s.s.

TABLE I

Linear dimensions in millimeters of *Pteria penguin* (Rŏding).

Particulars of dimensions	*Specimen* 1 (From Havelock Is.)		*Specimen* 2 (From Havelock Is.)		*Specimen* 3 (From Gulf of Mannar)	
	Right valve	Left valve	Right valve	Left valve	Right valve	Left valve
Hinge length ..	148	148	114*	115*	94	94
Umbo to anterior extremity of the hinge	24	25	25	25	34	32
Umbo to ventral extremity.. along the longest axis	186	185	124	123	156†	154†
Umbo to nacreous margin.. along the longest axis	127	152	85	106	116	150
Middle of byssal notch to.. anterior end of hinge	54	45	46	40	56	47
Length below the level of.. byssal notch	107	111	78	80	—	—
Thickness of the valve ..	20	32	16	22	34	32

* Tip of posterior auricle broken.
† Free borders broken.

The genus *Avicula* described by Reeve 1857 is synonymous with *Pteria* s.s. of Jameson. Two of the species figured by Reeve (1858) viz., *A. macroptera* and *A. lotorium* are of importance in assigning the systematic position of the Andaman shells. Most Conchologists are of the opinion that these two species are identical. Of the two species, *A. macroptera* has priority over *A. lotorium*. *Pinctada penguin* Röding 1798 having a priority over *A. macroptera* (Lamarck) and as the generic names *Pinctada* and *Avicula* are to be replaced by *Pteria*, the form should be named *Pteria penguin* (*vide* Prashad, 1932).

Some pearl wing shells from the pearl paars of the Gulf of Mannar off Tuticorin coast have also been examined and the dimensions of one of the shells are given in Table 1. As compared with the shells of the Andaman sea those of the Tuticorin coast are much thicker in texture, the anterior auricles in both the valves are well developed and the posterior auricles are much reduced. The general contour is the same in shells from both the localities. A pearl wing shell from the Gulf of Mannar has been described as *Pteria lotorium* (Lamarck) by Satyamurti (1959), the identification of the shell having been based upon the smallness of the anterior auricle, which with a truncated edge as shown in his text figure 2 on page 75 is apparently broken.

Prashad (1932) is of opinion that the Lamarckian species, *P. lotorium* is based on slightly different shells of his earlier species, *P. macroptera* and that these two species are therefore synonymous. The configuration of the auricles alone, which is subject to variation according to size as revealed by the examination of shells from the Andamans, is of little significance in determining the species. The shells from the Andaman sea and from the Gulf of Mannar are referable to *Pteria penguin* (Röding).

P. penguin is a widespread species and the extent of its distribution is from ' Australia to Madagascar ' (Prashad 1932). The species is common throughout the Indo-Pacific region. It abounds off the coasts of Japan and nearby islands where it is successfully employed by the Japanese technicians for culturing large sized hemispherical pearls.

The writer has great pleasure in offering his thanks to Dr. S. Jones for the interest he has shown in the preparation of this note and to Shri K. G. Nambiar for taking the photographs of the shells.

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A NOTE ON THE OCCURRENCE OF THE BLUE GREEN ALGA *APHANOCAPSA LITTORALIS* HANSG. VAR. *MACROCOCCA* HANSG. CAUSING COLOURATION OF THE SAND AND ITS RELATION WITH THE TIDES

Though there are many reports, from various parts of the world, about organisms inhabiting intertidal sands causing colouration and the tidal rhythm of the causative organisms, little attention seems to have been paid to these in India. Dixit (1936) reported the occurrence of *Aphanocapsa littoralis* var. *macrococca* on the Chowpathy sea-shore in Bombay but no information has been given about its relation with the tide. Recently, Ganapati, Rao and Rao (1959) reported the tidal rhythms of some diatoms and dinoflagellates inhabiting the intertidal sands of the Visakhapatnam Beach. The present note is based on the occurrence of a blue-green alga causing a green colouration of the sand at Karwar Beach in the North Kanara Coast.

At low tide, during February-April and sometimes also in August and October, the intertidal zone of the sandy beach is often found to exhibit widespread dull green colour which develops under the brilliance of the sun. Examination of this coloured sand revealed the presence of dense populations of *Aphanocapsa littoralis* Hansg. var. *macrococca* Hansg. adhering to the sand grains with the help of their mucilaginous envelope.

Individual cells varied from 3.5-6.0 μ in diameter and isolated individual cells kept in watch glasses showed active wriggling movement when agitated. Kept undisturbed, the cells clustered around the water margin in groups and adhered to the glass and the grains of sand.

During day time at low tide these organisms appear in thick, evenly spread, green patches in the sandy beach. At the time of high tide these green patches disappear and therefore, the occurrence of the colour seems to synchronize with the tidal periodicity.

It is observed, that no such colour develops in the beach when the low tide is exclusively confined to the night. However, the green patches that develop during day time at low tide continue to exist in the beach at night as long as that low tide remains. It shows that the development of the colour has some relation to light also and a more detailed study on this will throw light on the probable causes of this behaviour of the alga.

I am grateful to Dr. R. Prasanna Varma for identifying the alga. I wish to express my sincere thanks to Dr. R. Raghu Prasad, Research Officer (Marine Biology), Central Marine Fisheries Research Institute, Mandapam Camp, for helpful criticism.

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A VIVIPAROUS NEMATODE, *PHILOMETRA* SP. IN THE OVARIES OF *OTOLITHUS ARGENTEUS* (CUVIER)

While engaged in the study of spawning periodicity of certain teleostean fishes of Mangalore area, a parasitic nematode was observed in the ovary of *Otolithus argenteus* (Cuv.). The fish measuring 203 mm. in total length and harbouring the parasite within its gonads appeared to be normal in its external body features. The parasitised ovaries of the fish presented dark red colouration and through the semi-transparent ovarian walls some of the coils of the parasite within could be seen. Except in the anterior one-third of the left ovary and the apical region of the right one where a few ovarian immature eggs measuring 0.019 to 0.134 mm. were found, the rest of the space in both the ovaries was occupied by the coils of the parasite. When the coils were unravelled, it was observed that in the region of the oviduct the part of the body of the parasite lying within the left ovary was continuous with that lying in the right ovary.

The parasite worm which is a female is long and slender measuring 537 mm. in length and 1 to 1.5 mm. in diameter in the anterior and middle regions respectively. In the posterior region, however, the diameter is only about 0.5 mm. The anterior end is rounded having a mouth which is simple and without lip-like structures. The posterior end is bluntly rounded. The anal opening is sub-terminal. The uterine branches meet forming a continuous tube.

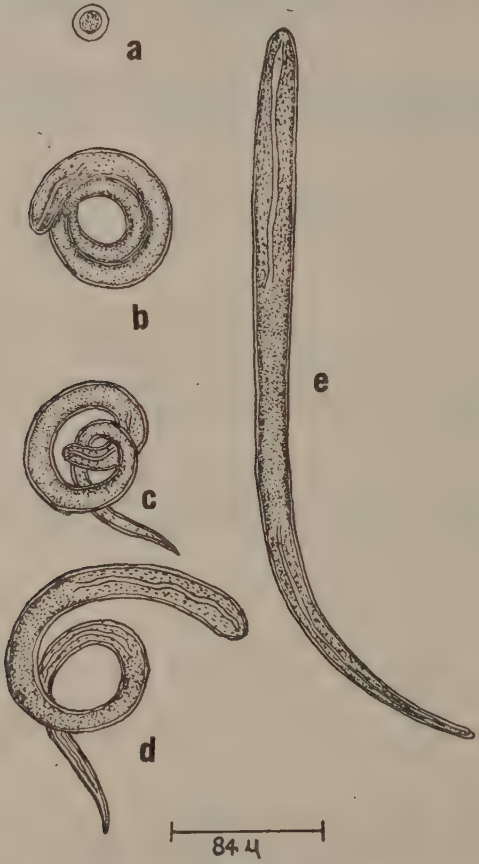

FIG. 1. Various stages of the developing stages of *Philometra* sp. (*a*) encysted egg. ; (*b*) coiled young parasite ; (*c, d*) stage of the parasite emerging from the cyst ; (*e*) completely uncoiled young parasite.

The parasite is viviparous and a large number of slender young ones varying in length from 0.30 to 0.67 mm. were found in the uterus. There were numerous encysted eggs in different stages of development. Some of the stages of the developing embryos are shown in Fig. 1 *a* to *e*.

The characters mentioned above agree very closely with those of the family Philometridae of the order Filarioidea, as given by Baylis (1939). The presence of a funnel shaped mouth, a short oesophagus and bluntly rounded short tail show that this form belongs to the genus *Philometra*, the adults of which are known to occur, ' in the body cavity, genital glands or connective tissues of fishes ' (Baylis, 1939).

In all cases where the adult males have been recorded they are known to be much smaller than the females. No adult males of this parasite were obtained and hence it was not possible to ascribe it to any known species under the genus *Philometra.*

It may be of interest to note here that larval forms of *Porrocaecum* spp. have been recorded from *Otholithus maculatus* (Cuvier) as cited by Baylis (1936).

The presence of parasite in the gonads is undoubtedly harmful to the host fish as has been evidenced by the atrophy of the major part of the ovaries except the apical regions where alone a few but very immature eggs were found in the specimen examined.

The writer wishes to express his sincere thanks to Shri R. Velappan Nair and Shri K. Virabhadra Rao, for their kind suggestions and criticisms in the preparation of this note.

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G. G. Annigeri

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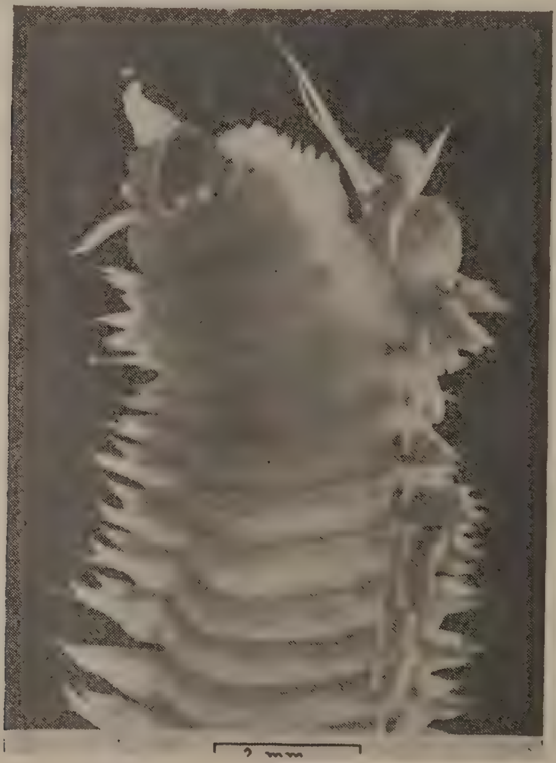
A NOTE ON AN ABNORMAL *LEONNATES JOUSSEAUMEI* GRAVIER (FAMILY NEREIDAE—POLYCHAETA)

The power of regeneration of lost or damaged parts in polychaetes is very well known. In most of the Nereidiform polychaetes new segments replace the lost segments and they can be generally recognised by being smaller than the rest at first. Moreover, not only can new segments arise at the hind end, but a new head can be formed at the anterior end. These regenerated heads are smaller at first than the rest of the body, but soon grow to a normal size. This extensive power of regeneration generally remains latent till injury provides the stimulus and is of extreme value to the polychaetes.

On 14-10-1961, a worm measuring 75 mm. (97 setigers) was collected by breaking open a dead coral stone taken from Palk Bay near Mandapam at a depth of 1 metre and was identified as *Leonnates jousseaumei* Gravier. Plate I shows the anterior end of the animal which exhibited an interesting type of abnormality. A dorsolateral split has occurred at the anterior end affecting the first three setigers only, as a result of which it is divided into two unequal members. The smaller member on the right side carries four tentacular cirri and a single poorly developed palp. The ventral portion is chitinized and all the mouth parts, except the soft paragnaths in the form of soft conical papillae, are missing. The larger member on the left side is more or less normal, slightly shifted towards the left from the median axis of the worm and carries a prostomium with four eyes, a single poorly developed palp, and a tentacular cirrus. The remaining three tentacular cirri are missing and their positions are indicated by three short cirrophores. The tentacles are also missing from the prostomium. The small horny paragnaths on the maxillary and the soft conical papillae on the oral rings of the proboscis, which carries a pair of curved horny jaws, are normal. The ventral side of the proboscis is not chitinized. The parapodia on either side of the affected segments are normal. From the 4th setiger onwards the animal is normal with a parapodia carrying a dorsal bundle of homogomph spinigerous setae and a ventral bundle of falcate homogomphs with the terminal pieces hooked at the apex and serrate on the convex border. The colour of the animal is dark brown with a brownish horizontal red line on each segment on the dorsal side. There is a dark spot also at the base of the dorsal rami in each segment.



We have not come across such a type of abnormality in Nereids so far and it is quite clear that an injury has occurred to the worm at the dorso-lateral angle affecting the first three anterior segments above the base of the parapodia and the healing has not united the damaged parts.

We wish to express our thanks to Mr. P. R. S. Tampi for the photograph.

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ON THE OCCURRENCE OF *MICROPROSTHEMA VALIDUM* STIMPSON IN INDIAN WATERS

Gravely (1927) recorded this species under the name *Stenopus robustus* and observed that it ' is not uncommon under stones on the reef south of Krusadai Island and in similar situations on Shingle Island '. Even though there is no reason to question the validity of the above observation, it is surprising that this species has not been recorded since then. I collected a single male from under the Adams bridge, Pamban, in 1959. The animal was found lurking in a depression on a submerged piece of rock, the colour of its translucent body harmonising very well with that of the stone. Scarcely was the animal touched with the tip of a forceps when it simply dropped its large chelipeds giving one the impression that it does not care the loss of such a formidable weapon. Autotomy is widespread among decapods, but it is generally resorted to as a means of escape. Here there was hardly sufficient provocation.

Holthuis (1946) has given a detailed description of this species emphasising its synonymy and intra-specific variation. In his subsequent publication (1955) he has reproduced Borradaile's (1910) figure which is not quite satisfactory. To my knowledge this species has not been satisfactorily figured. I give below a short illustrated description of this species so that the animal, if come across, could be easily distinguished by the successive batches of students who visit this locality every year.

Rostrum straight, reaching well beyond the antennular peduncle, with five dorsal spines, ventral or lateral spines absent. Dorsal surface of carapace spiny, lateral borders, especially its anterior half, with large spines. Cervical groove deep and arched forwards. Dorsal carina of first two abdominal segments very prominent, that of third indistinct. Telson as long as uropods, with a pronounced basal constriction, lateral border with two teeth, one median and the other distal, distal border of telson with a median spine, the border between the spines setose. Dorsal side of telson with two pairs of basal spines and two oblique longitudinal carinae, each with three sharp teeth.

Peduncle of the eye with three or four spines. Basal joint of antennular peduncle with a prominent stylocerite, second joint with a large outer and two small inner spines. Antennal scale broad, its outer border with three sharp spines behind the spine-like apex. Merus of second peraeopod with three denticles. Third peraeopod massive, merus and carpus triangular in cross section, edges spiny, some of the spines large. Propodus oblong, with pustulose surface and a high dorsal crest with spiny border. Dactylus curved, slightly longer than the fixed finger and with two teeth closing on either side of a single tooth on the fixed finger. Fourth and fifth legs subsimilar, propodus with a ventral row of fourteen to fifteen spines, carpus not divided, dactylus prominently biunguiculate. Exopod of uropod broader than endopod, its outer border with a row of ten teeth, the last tooth enlarged, dorsal

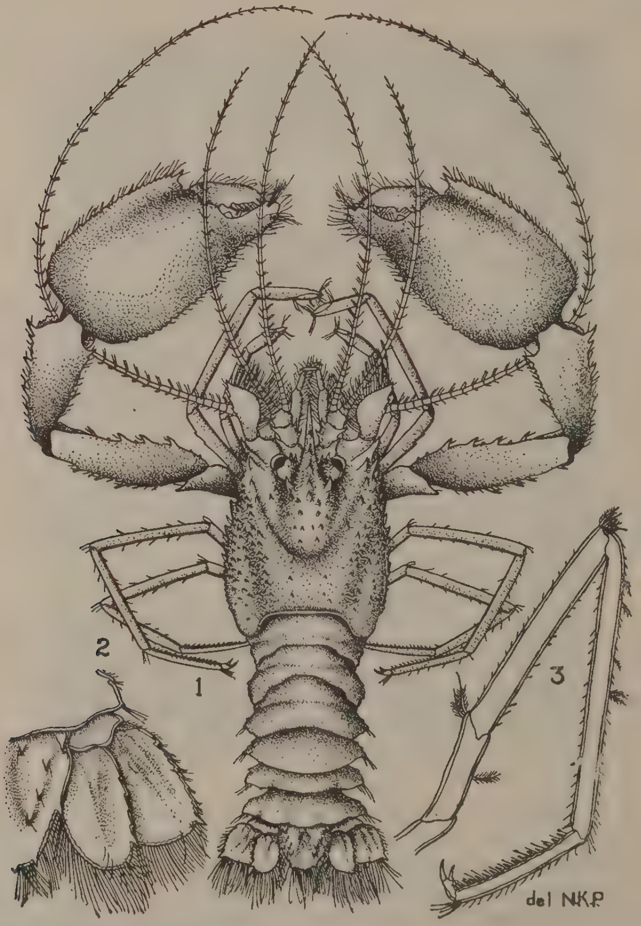

FIG. I. *Microprosthema validum* Stimpson. 1. male, dorsal view ; 2. uropod and telson ; 3. penultimate leg.

surface with two carinae. Endopod with a single dorsal carina, its outer border with five teeth, fifth tooth large and placed slightly away from the tip.

Total length 14.0 mm., length of carapace 6.0 mm.

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A RECORD OF *PANULIRUS PENICILLATUS* (OLIVIER) FROM THE INSHORE WATERS OFF QUILON (KERALA)*

Panulirus dasypus Latreille (Gravely 1927), *P. ornatus* Fabricius (Rai 1933 ; Chopra 1939 & 1943) and *P. polyphagus* Herbert (Chopra 1939 & 1943) and *P. burgeri* de Haan are the common species of lobsters recorded from the catches of the Indian coasts. In addition *P. versicolor* Latreille is not altogether uncommon along the Kerala coast. Alcock in 1901 described *P. angulatus* and indicated its availability in the Gulf of Mannar. This species is probably synonymous with *Peurulus sewelli* referred to in the scientific reports of the John Murray Expedition (Ramadan 1938). During the recent lobster gear investigations conducted from this Station with specially designed bottom-set gill nets along the south-west coast of India, in one net operated off Tangassery point (Quilon), a single large sized lobster, which is distinctly different from all others obtained at this place as well as from other fishing centres namely Varkala, Vizhinjam and Colachel-Muttam, was caught. On identification, it has been found to be *Panulirus penicillatus* (Olivier). So far the availability of this species and its occurrence along the Indian coasts have not been indicated in any of the published records.

The present note embodies a short description of the specimen collected at Quilon. According to the accounts of Barnard (1950), Sheard (1941) and especially de Man (1916), the general distribution of this species is throughout the whole of the Indo-Pacific from Gulf of Akaba to Fusan (Korea), Hawain and Gambier Islands, New Hebrides, East Indies, North coast of Australia, Pacific Islands and Red Sea.

Topography of the place of capture :—One unit of bottom set gill nets of length 250 meshes, depth 10 meshes and 6″ mesh made of nylon was set in the evening of 19-1-1960 at a place situated ½ a mile off Tangassery point (8° 53-54′ N Latitude and 76° 34′ E Longitude). The depth of water was between 3 and 3½ fathoms and bottom was sandy with patches of laterite rocks, covered predominantly with a weedy vegetation. A second unit of net was laid parallel about 100 yards away in depth between

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* *Contribution No.* 35 *from the Central Fisheries Technological Research Station* (*Craft and Gear Wing*), *Cochin.*

2½ and 3 fathoms. The weather was fair and sea calm with feeble currents. The nets remained overnight and they were hauled next morning. The first net unit was fully loaded with weeds and in addition to the specimens of *P. penicillatus* had as catch two perches, five small rays and one medium sized turtle. The second net unit recorded a catch of 22 lobsters (all *P. burgeri*) without any fish.

Brief description of the specimen :—The abdominal segments have transverse uninterrupted grooves and antennular segment has four conspicuous spines, each of the posterior spine being united at the base to its corresponding anterior spine (in conformity with the key of Barnard, *op. cit.*). The specimen is bluish green dorsally with light patches of different colours, and yellowish green ventrally with yellow spots, while all the legs have striking yellow longitudinal wavy lines on a light blue background. True to the popular name given to this species as ' Variegated cray fish ' the lobster looks as if brushed with a variety of different hues and colours by an expert artist.

The total length from antennular margin of carapace to posterior end of telson is 323 mm. while the length of carapace from anterior margin to its posterior end is 142 mm. The specimen is a female and weighed 1.13 kg.

ACKNOWLEDGEMENTS

My grateful thanks are due to Shri M. Krishna Menon, Research Officer, Central Marine Fisheries Research Sub-Station, Ernakulam, for his kind help in identifying the specimen. My thanks are also due to Shri G. K. Kuriyan, Assistant Director (Gear), Central Fisheries Technological Research Station, Cochin, for kindly going through the manuscript and suggesting improvements.

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OCCURRENCE OF A VERY EARLY STAGE OF *PARAPEGASUS NATANS* (LINNAEUS) FROM THE NEAR-SHORE WATERS OF PORTO NOVO, SOUTH INDIA

Three species of Pegasidae have so far been recorded from the Indian waters, viz., *Pegasus draconis* (L) by Day (1889) from the Andamans, *Parapegasus natans* (L) by Johnstone (1904) and by Munro (1955) from Ceylon, and *Parapegasus volans* (L) by Munro (1955), also from Ceylon. Jones and Pantulu (1958) recorded 23 post-larval stages of *Parapegasus natans* (L) from the Orissa coast. Of these, the earliest stage was reported to be 7.88 mm. in length.

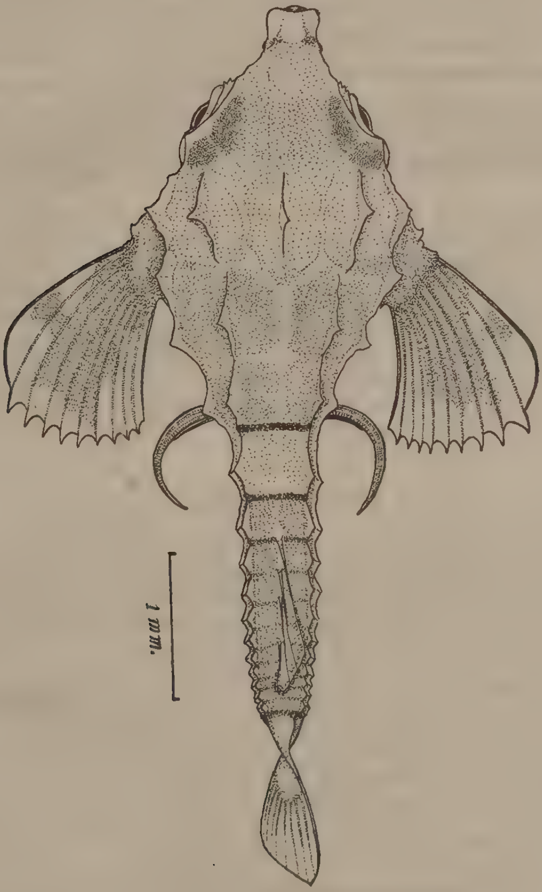

FIG. 1. Showing larva of *Parapegasus natans* (L)

The present note relates to the find of an earlier stage of *Parapegasus natans* (L) than has been known hitherto. A single larva of this species was obtained in the tow-net collection of plankton, taken at the 7-fathom line off Porto Novo, on the 23rd of July, 1961.

The measurements of the specimen are given below :

Total length	Head	Snout	Eye	Snout to Dorsal	Snout to Ventral.
6.00 mm.	2.00 mm.	0.32 mm.	0.13 mm.	3.49 mm.	2.84 mm.

The larva now recorded, shows an overall resemblance to the stage I of the specimen described by Jones and Pantulu (1958). However, the following characteristics of the larva collected from Porto Novo, are worth mentioning.

The general colour of the specimen, when alive, is dark brown. The tip of the upper jaw is flexed upwards and this makes the lower jaw appear longer when viewed dorsally. The body is covered with bony plates anchylosed on the trunk. When the specimen is viewed dorsally, there is a short ridge comprised of three plates between the base of the pectoral fin and the posterior margin of the eye. This probably corresponds to the ' small bony frill immediately behind the eyes', observed by Jones and Pantulu in stage I of the specimens collected by them. The caudal fin in the present specimen is devoid of any pigmentation and is very transparent, unlike what has been reported by Jones and Pantulu in the stage I of their specimen. The eyes are prominent and pigmented.

ACKNOWLEDGEMENTS

It is a pleasure to record my grateful thanks to Prof. R. V. Seshaiya, Director and Professor, Marine Biological Station, Porto Novo, for encouragement and interest, Dr. P. Vijayaraghavan for kindly help and Mr. T. N. C .Ramaprasad for help in preparing the figure. I am thankful also to the Council of Scientific and Industrial Research for the award of a Junior Research Fellowship.

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ON THE CAPTURE OF A BALEEN WHALE AT KAKINADA ON THE EAST COAST OF INDIA

On 19th July 1959 at about 19.00 hours, in the wake of a large wave fishermen from a boat sighted a whale in the shallow waters of Chollangi Bay near Etumoga Village, Kakinada. It was seen drifting as a long black mass with the dorsal fluke protruding conspicuously above the water. The men approached it in the boat and threw a rope on to the dorsal fluke, but the whale moved away too fast carrying the rope along with it. Realising the futility of tackling such a monstrous creature from one boat, the fishermen returned to the shore and immediately proceeded to the spot with two other boats and a total complement of 25 crew. The boats were plyed in such a way that the animal had to swim shore-wards. The boats were also kept reasonably close together to prevent its escape. In the last stages of the chase the animal actually ran aground frightened by the sound produced by beating the sides of the boats. Thus stranded, it was roped around the caudal region and hauled ashore by about 150 fishermen who formed part of the crowd watching the chase. After its capture the whale lived for about five hours and for sometime, soon after it was beached it roared repeatedly thereby attracting all the people from the village to the spot.

A temporary gunny enclosure was raised and the whale was kept on show from 20-7-1959 to 24-7-1959, during which time it was perfumed and disinfected with agarbathis, frankincense, napthalene powder, and ice in husk was also applied as a preservative. Fifteen to twenty thousand people from Kakinada and nearby villages visited the spot paying 12 nP. for viewing the animal, the fishermen thus realising about Rs. 2,000 as gate money.

The whale had the following measurements :

Total length	26′ 1″
Height of body	3′ 6″
Length of pectoral flipper	3′ 3″
Length of snout	5′ 6″
Width of snout	2′ 6″
Length of each caudal fluke from notch	3′ 4″
Approximate weight	8 tons.

The entrails of the animal were removed on 24-7-1959. On the following morning the carcass was handed over to the local authorities of the Fisheries Department who removed the eyes, the baleen plates, the pectoral flippers with the bones, and the dorsal fluke for preservation, while the blubber was also taken by them for the extraction of oil. The oil extracted by treating the blubber in boiling water was not of rich quality as the blubber was poor and thin, and the animal itself young and dead for some days. At about 18 hours on the same day, the remaining carcass was buried there itself so that the skeleton could be exhumed at a later date.

The presence of a pair of blow holes, baleen plates with edges of a light colour, prominent dorsal fluke, pectoral flippers, moderate and numerous ventral furrows ending well in front of the umbilicus indicate it to be a baleen whale of the genus *Balaenoptera*.

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C. LAKSHMANA RAO.

NEWS AND COMMENTS

Ninth IPFC Session

The ninth session of the Indo-Pacific Fisheries Council was held at Karachi from June 9 to June 23. The highlight of the proceedings was a symposium on formulating a programme of research and technological improvements, especially in fish handling, and methods of assessing progress in them.

The tenth session of the Council will be held at Seoul (South Korea), and the tentative date is September-October 1962. A symposium on the development of mechanical fishing fleets is proposed to be included.

Indian National Committee for Oceanographic Research

It is understood that the working groups of the INCOR have prepared a programme where 4 research vessels would be participating in the Indian Ocean Expedition for nearly 6 months each year during 1962 and 1963. The main areas to be covered by these Indian research ships will be the northern part of the Arabian Sea and the Bay of Bengal up to 12 degrees south latitude, while on the west it will be from 60 degrees longitude to the Sumatra coast on the east.

The Scientific personnel required for work will be drawn from the various governmental organisations and maritime Universities. The principal fields in which work will be carried out are Meteorology, Physical and Chemical Oceanography, Marine Geology and Geophysics, and Marine Biology and Fisheries.

In this connection Dr. R. Raghu Prasad and Dr. P. N. Ganapati (who are also the Secretary and Editor respectively of the Marine Biological Association of India) represented India at the meeting of zooplanktologists held at Cochin in August 1961. Subsequently, Dr. R. Raghu Prasad and Mr. R. Jayaraman participated in the conference on International Intercaliberation Tests of Nutrient Chemistry and Primary Production Techniques. Dr. N. K. Panikkar, Secretary of the INCOR, attended the SCOR meetings at Paris and Monaco.

Considering the topical significance and the rôle our country is playing in this co-operative research venture, it is encouraging to learn that the SCOR and the U.S. Biological Group have agreed on the selection of Cochin as a centre to facilitate the handling and distribution of biological material that will be collected by the participating vessels.

Research Cruises

The CSIRO oceanographic research cruise off Western Australia during February-March by HMAS '*DIAMANTINA*' as part of their Indian Ocean programme included traverses of the reported *Diamantina Deep*. HMAS '*GASCOYNE*' also undertook, during the same period, cruises in the western section of the Great Australian Bight as part of CSIRO's south-eastern pelagic fisheries research programme.

According to an announcement from the Scripps Institution of Oceanography of the University of California, two of their research vessels '*STRANGER*' and '*HUGH M. SMITH*' would operate in the Bering Sea and the Gulf of Alaska from July to September 1962, on what has been styled as the *Leapfrog Expedition*. The trip is primarily for seismic refraction and heat flow measurements, and the results are awaited.

Another expedition designated as *Risepac* is programmed for the Fall and Winter of 1961-62, for geophysical-geological investigations in the eastern tropical Pacific. The programme will also include water sampling for C^{14} studies.

Plankton Under Ice

The nuclear submarine '*SEA DRAGON*' has been able to collect samples of plankton under the polar ice for the first time during her voyage from Portsmouth, N.H., to Pearl Harbour, Hawaii, by way of the North Pole. The device used was an automatic sampler, somewhat like an automatic soft drink dispenser.

Upwelling Near Sea Surface Measured

The U.S. Navy's Electronic Laboratory at San Diego (California) has reported that her scientists have been able to measure for the first time distinct sinking and upwelling of water masses near the surface. The currents could continually bring up food from the depths for the surface marine life and also take down the surface food, such as plankton, for the larger fish in the deeper depths. Thus, knowledge of these currents is very desirable for the study of distribution of food for marine life.

Similar investigations in the Atlantic Ocean, Indian Ocean, and the Gulf of Mexico strongly indicate that the vertical current movements is worldwide. The origin of the ' internal waves ' is still a mystery. Some scientists believe storms far out at sea start the waves ; others think they are due to cold and warm layers meeting.

U.S. Sea Research Grant

The U.S. President, in his message to Congress, has asked for 97½ million dollars for the fiscal year 1962 for a national oceanographic programme. While disclosing the advantages of additional knowledge of the oceans by way of increasing the nutritional and mineral resources, the President has rightly pointed out the fact that we are just at the threshold of our knowledge of the oceans. The President's programme also provides for training oceanographers and for international co-operation.

THE SNORKEL LEAGUE

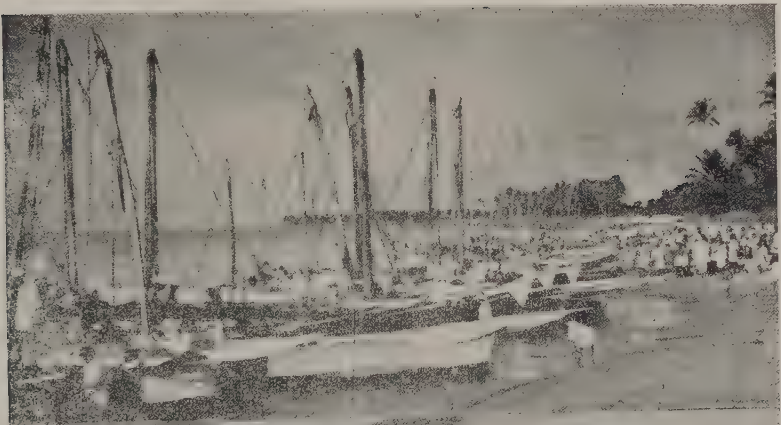
The highlight of the activities of the Snorkel League during the year was a regatta and aquatic sports organised by the League in collaboration with the Collector and Revenue Officials of Ramanathapuram District on February 3rd, 1961 in connection with the visit of His Excellency the Governor of Madras, Shri Bishnuram Medhi who is also the Patron-in-Chief of the Marine Biological Association of India. The venue of the regatta was the Gulf of Mannar, opposite the Central Marine Fisheries Research Institute. Various types of fishing crafts like *Chiraguketti* (Muthupet Boat), Tuticorin Boats and Malabar Canoes, drawn from several coastal villages, took part in the regatta (Plate). Other competitions in the aquatic sports included diving and freestyle swimming. One of the most colourful items was the target swimming with mask and snorkel by the members of the Snorkel League. Three cups donated by Shri Kasi Viswanathan, Director, Industrial Chemicals Ltd., Sankaranagar, were awarded to the winner, Shri P. Sulochanan, and the runners-up, Sarvashri, S. Mahadevan and K. Nagappan Nair, all members of the League. The Governor evinced keen interest in this item and the President of the Association presented him with a mask and snorkel. The Championship cup donated by Shri P. R. M. K. M. Abdul Kader Marakkayar and Shri P. R. M. K. M. Kasim Mohamed Marakkayar of Mandapam, was won by the Pamban village. The event terminated with a gorgeous march past of Pablo Boats when the Governor took the salute.

It is expected that the regatta will be an annual feature and that it will help in securing the hearty co-operation of the coastal villages in an atmosphere of healthy and friendly competition. It will undoubtedly have a tremendous effect on stimulating Government's efforts in stabilising and improving the Fishing Industry in this District.

On 4th February 1961, during the annual general body meeting of the Marine Biological Association of India a Silver Snorkel was presented by the President to Shri C. Sankarankutty, who won the Championship in the aquatic sports held in Palk Bay on 28th May 1960.

Snorkelling conducted in Palk Bay continued to attract several enthusiasts. Distinguished guests who took part in snorkelling during the year include Dr. Sen, Member, Union Public Service Commission, Shri E. C. P. Prabhakar, Collector of Ramanathapuram and several officers of I.N.S. ' *JUMNA* '.

Convener.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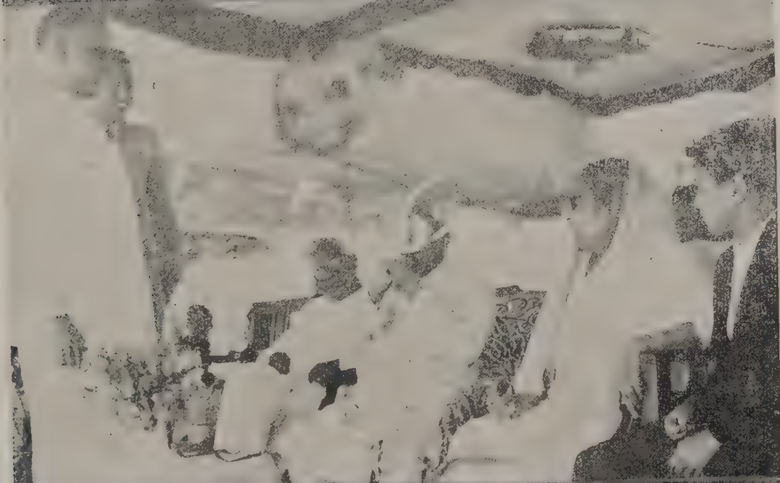
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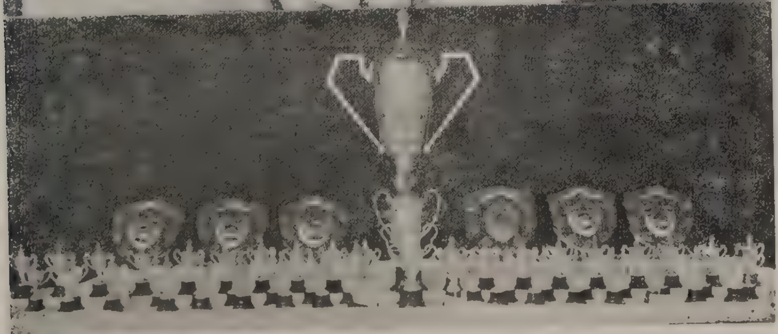
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1. The boats that participated in the regatta. 2. H. E. The Governor, Patron-in-Chief of the Association trying the mask and snorkel. 3. The shields and cups presented on the occasion. The championship cup is in the middle.

AMENDMENTS TO THE CONSTITUTION

The following amendments to the Constitution were passed at the Third General Body Meeting held on January 6, 1962

Article 15 of the Constitution :—

‘ **Executive Council :** The Association shall be administered by a President, a Vice-President, two Secretaries, a Treasurer, an Editor of the Journal and six members. Either the President or the Vice-President, the Treasurer and one of the Secretaries shall be residents at the Headquarters of the Association. The Resident Secretary with the approval of the Executive Council shall appoint an Assistant Secretary to help him. In the absence of the Secretary in any meeting of the Executive Council the Assistant Secretary will be co-opted and his presence shall count toward the required quorum. The Treasurer with the approval of the Executive Council shall appoint an Assistant Treasurer to help him. In the absence of the Treasurer in any meeting of the Executive Council the Assistant Treasurer will be co-opted and his presence shall count toward the required quorum. The Assistant Secretary and the Assistant Treasurer shall be residents at the Headquarters of the Association.’

amended to read as :—

‘ **Executive Council :** The Association shall be administered by a President, two Vice-Presidents, a Secretary, a Treasurer, an Editor of the Journal and six members. Either the President or one of the Vice-Presidents, the Secretary and the Treasurer shall be residents at the Headquarters of the Association. The Secretary with the approval of the Executive Council shall appoint an Assistant Secretary to help him. In the absence of the Secretary in any meeting of the Executive Council the Assistant Secretary will be co-opted and his presence shall count toward the required quorum. The Treasurer with the approval of the Executive Council shall appoint an Assistant Treasurer to help him. In the absence of the Treasurer in any meeting of the Executive Council, the Assistant Treasurer will be co-opted and his presence shall count toward the required quorum. The Assistant Secretary and the Assistant Treasurer shall be resident at the Headquarters of the Association.’

Article 22 of the Constitution :—

‘ The accounts of the Association shall be audited annually by a committee of two persons appointed by the Executive Council.’

amended to read as :—

‘ The accounts of the Association shall be checked and verified annually by a committee of two persons appointed by the Executive Council, and audited by a registered accountant. The Treasurer or in his absence the Assistant Treasurer shall present the audited statement of accounts to the members at the following general body meeting.’

Article 24 of the Constitution :—

‘ The Annual General Body Meeting will be held ordinarily between December 15 and January 15.’

amended to read as :—

‘ The Annual General Body Meeting will be held ordinarily between January 15 and February 15.’

ANNUAL REPORT OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA FOR THE YEAR ENDING 1961

Mr. President and members of the Association,

On behalf of the Executive Council, I have great pleasure in presenting the third Annual Report of the Marine Biological Association of India.

During the period under review, the Association made steady progress in its activities. The membership of the Association as on 31-12-1961 stands as follows :—

Life Members	.. 11
Ordinary Members	.. 204
Institutional Members	.. 59

There has been a steady increase in foreign membership, while Indian membership indicated a small decline. This may be because of the delay in issuing the Journal of the Association and it is hoped that in the near future the Journal will be issued more regularly which would attract more Indian members.

Under the auspices of the Association, two meetings were held—one ' On sex reversal in Crustacea ' by Mrs. Charniau Cotton in July and the other ' On Marking of Shrimps in the U.S.A.' by Mr. M. J. George in August.

The Snorkel League of the Association had been very active and it is gratifying to note that the Leaguers have contributed much in creating interest in the study of marine life in the field. The highlight of the activities of the Snorkel League during the year was a regatta and aquatic sports organised by the League with the active co-operation of the Collector and Revenue Officials of Ramanathapuram on February 3, 1961, in connection with the visit of His Excellency the Governor of Madras, Sri Bishnuram Medhi who is also the Patron-in-Chief of the Association. Snorkelling conducted in Palk Bay during the calm season continued to attract several enthusiasts.

Local branches were started at Tuticorin and Madras and the total number of branches stands at 5.

The Treasurer and the Managing Editor will be presenting their reports separately. It may be said that the Journal of the Association has been well received by the scientific public and in spite of the very limited funds at the disposal of the Association, every effort is being made to keep up the standard of the Journal and its regular publication.

Before I place this report for your approval, let me take this opportunity on behalf of the office-bearers and the Executive Council, to thank all the members for their continued support and co-operation. In my capacity as Resident Secretary, I would like to place on record my gratitude to the President, other members of the Executive Council and the Associate office-bearers, particularly Dr. R. P. Varma, the Assistant Secretary, for their willing help and sincere co-operation.

Thank you all.

Confirmed
(SD.) S. JONES,
(*President*).
6-1-1962.

(SD.) R. RAGHU PRASAD,
(*Resident Secretary*).

TREASURER'S REPORT FOR THE YEAR 1961

Dear Mr. President and Fellow Members of the Association,

In accordance with the right conferred by the Constitution, I have the privilege and the honour to present the following Statements of Accounts for the year ended the 31st December, 1961 :

As may be seen from the statements, the total amount of subscriptions of Rs. 7394.66 includes Life Membership Subscriptions, there being four additional members during the current year, bringing the total of life members to 11 as against 7 at the end of the year 1960. Towards the cost of printing of the Journal, Vol. II, Nos. (1) and (2), an expenditure of R. 7296.39 has been incurred as against Rs. 3878.15 only in the previous year for printing Vol. I, No. (2). By sale of publications etc., an amount of Rs. 1649.53 has been realised as against Rs. 578.92 during the year 1960. The additional income under this head during the current year is mostly from the sale of the copies of Vol. I of the Journal to Institutional Members. An estimated expenditure of Rs. 7300 for printing Vol. III Nos. (1) and (2) which is due to members against 1961 subscriptions has been included leaving a deficit of Rs. 6915.26. A certain amount of arrears of 1961 subscription due from the members when recovered will cover only a fraction of the deficit. The general overall expenditure has been kept at an essential minimum and it may not be possible to reduce it any further. By the rapid rise in the number of enrolment of members which stands at 866, it is evident that the journal is serving a very useful purpose to various scientific workers within India and abroad. To all members and public organisations, we appeal to come forward with liberal donations to meet this deficit.

I take this opportunity to offer my sincerest gratitude to Shri S. Mahadevan who officiated as Assistant Treasurer till August and Shri K. Krishna Rao who assisted me in the succeeding period during the year for having attended to all the routine duties of the Treasurer. To Shri P. S. S. Sarma and Shri K. Alagarswamy, I am thankful for assistance rendered in maintaining some of the Registers etc. My thanks are due in no small measure to Shri D. Chakraborty and Sri S. Rajagopalan for having gone through very patiently and scrutinised all the Registers to enable me to present the Statements of Accounts accompanying this Report.

Thank you all.

Mandapam Camp,
6-1-1962.

(Sd.) K. V. Rao,
(*Treasurer*)

(Sd.) S. Jones,
(*President*)

AUDIT REPORT

To

The Members of the Association,
Marine Biological Association of India,
Mandapam, Ramnad District, South India.

I have examined the Balance Sheet as at the 31st December, 1961 and the Receipts and Payments Statement and the Income and Expenditure Account for the year ended the 31st December, 1961, annexed hereto, with the books of account of the Association, Counterfoils of the receipt books and vouchers produced to me and obtained all the information and explanations I have required.

The books of account produced to me record only the cash receipts and payments. The Balance Sheet and Income and Expenditure Account given are according to the books of account produced to me and information and explanations received. The charges for printing Volume III, Nos. 1 & 2 of the Journal are provided for on an estimate in the Income and Expenditure Account and shown in the Balance Sheet as a liability.

Subject to my foregoing remarks, I certify, to the best of my knowledge and belief, that the Balance Sheet and the Receipts and Payments Statement and the Income and Expenditure Account, annexed hereto, are true and correct as shown by the books of account maintained and the information and explanations received.

Madurai,
May 19, 1962.

(Sd.) S. K. SRINIVASAN,
Chartered Accountant.

MARINE BIOLOGICAL ASSOCIATION OF INDIA, MANDAPAM.

Balance Sheet as on the 31st December, 1961.

LIABILITIES	Rs. nP.	ASSETS	Rs. nP.	Rs. nP.
Liability for printing charges of Vol. III Nos. 1 & 2 as provided for on estimate.	7,300.00	Fixed Deposits with State Bank of India, Ramnad.		2,000.00
		Balances at credit with Banks :		
		With State Bank of India, Ramnad ..	1,941.49	
		With State Bank of India, Madras ..	500.00	
		With Lloyds Bank, Madras ..	333.98	2,775.47
		Cash Balances :		
		With Joint Editor—on Advance account	24.66	
		With the Treasurer	180.36	205.02
		Income & Expenditure account Balance		2,319.51
Total ..	7,300.00	Total ..		7,300.00

Presented by
K. VIRABHADRA RAO,
Treasurer.

Checked by
D. CHAKRABORTY,
S. RAJAGOPALAN.

Examined and found correct
Subject to my report of even date.
(Sd.) S. K. SRINIVASAN,
Chartered Accountant.

MARINE BIOLOGICAL ASSOCIATION OF INDIA, MANDAPAM

Income and Expenditure Account for the year ended the 31st December, 1961

EXPENDITURE

	Dr. Rs. nP.	Rs. nP.
To *Sundry Expenses* :		
Printing and Stationery	288.04	
Postage	1,218.76	
Bank Commission	111.98	
Honorarium for accounts work	200.00	
Honorarium for typing work	240.00	
Miscellaneous	105.56	
		2,164.44
To Cost of Reprints		458.80
,, Charges for printing Volume III, Nos. 1 & 2 of the Journal as provided for on estimate		7,300.00
,, Balance-Excess of Income over Expenditure for the year—carried down		884.74
		10,807.98
To Excess of expenditure over Income for the year ended the 31st December, 1960, adjusted and brought forward :		
Balance as per account	6,084.43	
Less : Charges for printing Journal, Volume I, No. 2 provided for on estimate in the account for the year ended the 31st December, 1959, written back	3,500.00	
		2,584.43
To Excess of expenditure over Income for the period 17th December, 1958 to 31st December 1959, adjusted and brought forward :		
Balance as per account	779.98	
Less : Subscriptions received in advance written back	160.16	
		619.82
Total		3,204.25

INCOME

	Cr. Rs. nP.	Rs. nP.
By Entrance fees		480.00
,, Subscriptions		7,394.66
,, Charges for advertisements in the Journal.		611.47
,, Interest on Fixed Deposits		75.00
,, Sales of reprints and publications		1,649.53
,, Miscellaneous receipts		93.71
,, Excess charges provided for on estimate in the account for the year ended 31st December, 1960, for printing Volume II, Nos. 1 & 2, now written back :		
Estimated charges provided for	7,800.00	
Less : Charges paid during the year	7,296.39	
		503.61
		10,807.98
By Balance brought down		884.74
By Balance carried forward		2,319.51
Total		3,204.25

MARINE BIOLOGICAL ASSOCIATION OF INDIA, MANDAPAM

Statement of Receipts and Payments for the year ended the 31st December, 1961

RECEIPTS

	Rs. nP.	Rs. nP.
Balances of Cash on 1-1-1961 :		
With the Treasurer..	219.47	
With O[illegible] on Advance Accounts..	48.32	
With State Bank of India, Ramnad. ..	2,891.88	
With Lloyds Bank, Madras.	436.08	
		3,595.75
Fixed Deposit with State Bank of India, Ramnad.		1,000.00
Entrance Fees.		480.00
Subscriptions :		
Life-members	565.80	
Ordinary members..	6,828.86	
		7,394.66
Charges for advertisements in Journals ..	611.47	
Sales of Publications and Reprints ..	1,649.53	
Interest on Fixed Deposits with State Bank of India, Ramnad	75.00	
Miscellaneous receipts	93.71	
Total ..		14,900.12

PAYMENTS

	Rs. nP.	Rs. nP.
Expenses :		
Printing and Stationery	288.04	
Postage	1,218.76	
Bank commission	111.98	
Honorarium paid for accounts work ..	200.00	
Honorarium paid for typing work ..	240.00	
Miscellaneous	105.66	
		2,164.44
Charges paid for printing of Journal Vol. II, Nos. 1 & 2, including cost of Blocks ..		7,296.39
Cost of reprints		458.80
Fixed Deposits with State Bank of India, Ramnad		2,000.00
Balances of cash on 31-12-61 :		
With the State Bank of India, Ramnad ..	1,941.49	
With State Bank of India, Madras ..	500.00	
With Lloyds Bank, Madras ..	333.98	
With the Joint Editor on Advance account	24.66	
With the Treasurer..	180.36	
		2,980.49
Total		14,900.12

Examined and found correct subject to my report of even date.

Presented by

(Sd.) K. Virabhadra Rao,
Treasurer.

Checked by

(Sd.) D. Chakraborty.
(Sd.) S. Rajagopalan,

(Sd.) S. K. Srinivasan.
Chartered Accountant.

REPORT OF THE MANAGING EDITOR

Mr. President and Fellow Members of the Association :

On behalf of the Editorial Committee I have the honour to present to you the Annual Report for the year 1961, relating to the Journal of the Marine Biological Association of India.

During the course of the year the two numbers of Volume II for 1960 were brought out. To all the members who would have been eagerly awaiting the publication of the Journal this delay would, no doubt, be a matter of disappointment. Our foreign subscribers would have been even further inconvenienced due to some delay caused by certain restrictions imposed in the postal despatch of the Journal. However, I am happy to say that this difficulty has since been overcome and the necessary permit has been obtained. The Editorial Committee would like to express their sincere regret over all this delay, but it has to be pointed out that much of the delay has been unavoidable. Our printers who have been doing the job efficiently have assured us again to minimise the existing delay and we hope to bring the schedule of publication up-to-date during the next year.

Besides the Diocesan Press, we wish to thank the Society of Electronic Engineers, Bangalore, and the Rathna Process, Sivakasi, who have prepared most of the blocks used in the printing of Volume II.

Confirmed
(Sd.) S. Jones,
(*President*)

(Sd.) P. R. Sadasivan Tampi,
(*Managing Editor*)

BOOK REVIEW

OCEANOGRAPHY—Edited by Mary Sears. (Invited Lectures presented at the International Congress held in New York in 1959) pp. 654. Publication No. 67 of the American Association for the Advancement of Science, 1961.

The study of the oceans has made rapid advances in recent years, and is now in a new phase of remarkable development. Techniques and instruments undreamt of before have opened new possibilities for intensive investigations, and with the bathyscape there is now the prospect of gaining direct knowledge of all the ocean depths. The new ventures in oceanography are characterised by their emphasis on the international aspects of the science, and by the realisation that oceanography is the meeting place of all sciences.

The book under review, which reflects this new phase of development in oceanography, comprises thirty-three invited lectures presented at the International Oceanographic Congress held in New York in 1959. These lectures, as pointed out in the preface to the book, do not aim at a summary of all existing knowledge about the oceans, but ' are focussed on certain problems that have been attacked in recent years with the co-ordinated application of recent advances in all the basic sciences'. Reading through the book, one comes across a note or two of anxiety about what the atomic madness, which now possesses mankind, may lead to. The overall impression produced by the book is confidence in the current achievements and robust optimism in the future promise of oceanography.

The papers reported in the book are grouped under five sections, viz., (1) History of the Oceans. (2) Populations of the sea. (3) The Deep sea. (4) Boundaries of the sea, and (5) Cycles ot organic and inorganic substances in the ocean. Twelve of the papers lay special emphasis on the biological aspects of oceanography. The origin of life is discussed in two papers, one by Bernal and the other by Oparin. Life, like Aphrodite, writes Bernal, was born on the sea foam, and less poetically but more correctly, it may be likened to the wind skimming the scum of the oceanic cooking pot and depositing it on the beach. The organic molecules which preceded life were deposited in the mud on the seashore, particularly estuarine muds. Recent studies of carbonaceous meteorites, Bernal points out, have yielded new evidence, which sets the first purely chemical stages of the origin of life further back to at least about 4,000 million years.

' The Biologist Poses Some Problems ' is the title of a paper by Hutchinson, in which he discusses among other things the evolution of the differences between sea-water and body fluids, and also why the fossilized remains of animals are almost absent up to the Cambrian Period and then appear in large numbers. The need for ethological work related to animals of major economic importance is emphasised by H. O. Bull. The length of larval life in marine bottom invertebrates, evolution in the deep sea, nature, origin, distribution of benthic organisms and their influence on sedimentation are some of the topics of biological interest discussed at the conference.

Is there really any subject that can be called primary production ? Steele thinks that primary production is rather a phrase used as focus for many diverse interests connected with what may be called rather vaguely the relation between phytoplankton and the environment. The usefulness of investigations of primary production, Steele points out, depends on the hydrographic structure of the locality, and one is likely to get a sort of randomness of data, if problems of primary production are chosen on the basis of the economic importance of fisheries rather than on the simplicity of the main feature of the environment. It appears, therefore, that the usefulness of data on primary production for fishery problems is still limited.

The web of inter-relationships, or the ‘ parabalance ’ between phytoplankton, zooplankton. modifying nutrients, light, turbulence and tripton.—the ‘balance between living and dead matter in the oceans ’—is discussed by Krey. An illuminating study of biogeographical boundaries with reference to plankton populations is presented by R. S. Glover, who incidentally pleads for more and better quantitative techniques in the study of the heterogeneity of phytoplankton communities. Speaking on certain quantitative characteristics of pelagic bottom life, Zenkevitch points out how essential it is to develop and expand the quantitative investigations of the composition of various biological and biochemical processes in the ocean.

The dynamic processes, geological, geophysical, physical and chemical aspects of the oceans are dealt with in the remaining papers. The significance of the differences in the structure between the Mid-Atlantic Ridge and typical land systems and of the tendency of the Ridge to bisect the ocean, the importance of the knowledge of the upper mantle in the ocean for theories of the origin of continents and oceans are discussed by Ewing and Landisman in a paper on ‘ shape and structure of Ocean Basins’. Forces and processes at work in the ocean basins, exchange of matter between atmosphere and sea, estuarine model of the Sub-Arctic Pacific Ocean, vertical and horizontal movements in the ocean,—these are some of the other papers dealing with the dynamic aspects of the ocean.

Discussing turbulent transport, Malkus mentions that even the simplest geometric quantity—the area of warm layer of the ocean—is an ever changing turbulent process, whose dynamics must one day be studied. Weilander Pierre in his paper on coupling between sea and air discusses the mechanical and thermodynamic processes at the sea surface in determining the physical state and dynamics of the oceans and feed-back links between the atmosphere and sea. The thermal effects from the sea must be studied and the feed-back effects will have to be considered to make good long-range weather forecasts. The characteristic responses of the sea to different mechanical and thermodynamical perturbations are important in this context. The rate of exchange of matter between atmosphere and sea has not been studied to any great extent in the past except for water vapour. Speaking on this subject, Erkisson emphasises the usefulness of a study of the geographical and seasonal variations of the vertical transport velocity and of relating it to wind stress and stability of surface water.

Cooper, L.H.N., presents a stimulating review of seven years' work relating to vertical and horizontal transport in the Atlantic. Evidence is presented for inferring that below 2,000 metres there is a multiple sandwich structure consisting of a series of layers in completely adiabatic equilibrium, and for which there is a rectilinear relationship between temperature and salinity, and between potential temperature and oxygen. It is suggested that each discontinuity provides rather a different biological habitat from others. An observer in bathyscape might identify indicator species for each of these discontinuities.

The geochemistry of radio-active elements in the ocean and the chronology of the deep sea sediments, geochemistry and physics of ocean circulation, geological record of the ocean floor, pelagic sediments, palaeobiogeography of the marine realm are some of the papers with geophysical, geological or geochemical emphasis. An interesting account of epicontinental sedimentation with some emphasis on the process of accumulation of clay in tidal flats is given by Kuenen. Lars Gunner Sillen discusses the physical chemistry of sea water with special reference to equilibria in the ocean. Concepts in modern chemistry should provide, according to Goldberg, an entry into a host of problems confronting the marine chemist. The geochemical behaviour of elements during their residence in the sea and subsequent to their introduction from the continents and atmosphere has provided the background for many recent investigations. The naturally produced isotopes Be^{10} and Si^{32} have been initially found in the marine realm. Si^{32} has been observed in siliceous sponges. The marine realm provides the unique sites for the accumulation of these radio-active species in amounts readily extractable for quantitative assay.

It is difficult in a review to do full justice to the excellent exposition of diverse and intricate problems covered by the lectures. In tune with the aims of the Congress, all the lectures keep constantly in view the expanding horizons in the subject. Oceanography, writes Roger Reville in the preface to the book, is full of new men, with new ideas and new skills for attacking and solving the problems of the sea. The thirty-three papers in the book justify this optimism, for they smack of youthful vigour, originality and intellectual enterprise in approach and exposition.

The book is well edited and the format is quite good.

R. V. SESHAIYA.

DASYATIS (The Sting Ray)—By Mary Chandy, in Memoirs of Indian Animal Types edited by Professor M. L. Bhatia, 1957, 123 pp., Text-Figures 62 (Publishers : Maxwell Company Private Ltd., Gautam Budh Marg, Lucknow ; Distributors : Atma Ram & Sons, Booksellers, Kashmere Gate, Delhi-6).

Like the Indian Zoological Memoirs edited by the late Professor K. N. Bahl the present series of which ' Dasyatis ' forms the first and the only memoir so far issued is intended to present a monographic account of the fundamentals of taxonomy and structural organisation of each one of the animal types to aid the teacher and the taught in the graduate and the undergraduate courses of study in zoology at the educational institutions. As a companion volume to the Indian Zoological Memoir on ' *Scoliodon* ' the present Memoir on *Dasyatis* will not fail to serve a very useful purpose in dealing with the animal types as these two represent two distinct super-orders, the Selachoidei and the Batoidei to include the sharks and the rays respectively under the only surviving group, the Selachii of the elasmobranch fishes.

The Memoir on *Dasyatis* begins with an introductory chapter on the systematics of the Batoidei with analyses of the genera, the sub-genera and species of rays based on the recent and widely accepted classification of fishes by L. A. Berg. The synonyms are presented in a historical background with a brief discussion, establishing the validity of the generic name, *Dasyatis* for the sting ray which is better known as *Trygon*. In the next ten chapters a comprehensive account of the external and internal morphology of different systems and organs is given with suitable illustrations. The descriptions are of conventional style using appropriate terminology to denote either the specific structures in an individual or their relative positions in a composite organism or their special modifications as compared with the same occurring in identical or related groups.

The distribution, habits and economic importance of the sting rays are given in a separate chapter following the anatomical descriptions. Of particular interest are some of the highly specialised adaptations of the rays for life at the sea bottom as also the viviparous mode of bringing forth their young. It is claimed that the rays contribute from 22 to 24% of the marine fishes of India. Authentic records of the All-India figures in recent years up to 1960, however, show that all the Elasmobranchs together do not exceed 6% of the total marine fish landings. Of them the sharks form the major portion and the skates and rays only a negligible quantity.

The final chapter deals with directions for practical work and is followed by a bibliography of selected references. There are a few printer's errors like ' Dasyatta ' for ' Dasyatis ' in table of contents on page i, line 8 ; ' genericme an' for ' generic name ' on page 9, last line ; ' floiwng ' for ' flowing ' on page 61, para 2, 6th line ; ' before its ' for ' before it ' on page 66, para 3, 8th line. These can be avoided in the next edition.

The memoir is well written and adequately illustrated. It will prove as a useful field and laboratory guide. It is hoped that more monographs under the series of the Indian Animal Types will follow soon.

K. V. Rao.

THE OCEAN—By F. D. Ommanney, Second Edition, 1961, pp. 244, 12 illustrations and 4 Plates, Oxford University Press, Price 8*s*. 6*d*. (U.K.) (Rs. 6.80).

The latest revised edition of Dr. Ommanney's book *The Ocean* is, indeed, a valuable addition to the library of popular oceanographic literature.

Oceanography which has been, hitherto, the common meeting ground of several basic sciences is fast becoming a single scientific discipline with its own unique techniques and methodology. The increasing number of oceanographic expeditions in recent years has resulted in unravelling the mysteries of the great ocean depths which have hitherto remained a challenge to mankind. Along with the marine scientist, the layman is coming to take more and more interest in the Seas that surround him and books of the type reviewed herein play a very important part in satisfying the needs and curiosities of the layman without whose sympathy, scientific progress would be too slow.

Dr. Ommanney has, indeed, done a good job in compressing into this small volume quite a treasure of information without omitting a single essential detail and his style of presentation is not only simple but lucid and impressive too. Commencing from the structure, physics and chemistry of the oceans, the author takes us on to a general account of the life in the oceans, and thence to a more detailed description of the ' inhabitants ' and the living conditions in the different zones constituting the hydrosphere such as shore, shelf and abyss. The economically important fishes and the whales, have also been given their due share of importance in this volume.

The use of instruments and the methods in oceanographic research are briefly discussed at the end and the reader is given a glimpse of the arduous conditions under which much of the information about the Seas have been obtained in the earlier years and also how the collection of data has been made more simple with the modernization of instrumentations and techniques.

The book makes very easy reading and both the Home University Library and the Oxford University Press must be complimented on the elegant get-up of the book. Although coloured plates and photographs have been omitted, probably with a view to making this edition cheap, the inclusion of these would have been more desirable to make the book more attractive and popular.

R. JAYARAMAN.

ON MALAYAN SHORES—By S. H. Chaung, Published by Muwu Shosa, P.O. Box 1813, Singapore, 225 pages, 113 plates, Price $8.00 (Malayan).

The intertidal region of the sea coast, with its variety of fauna and flora, presents a fascinating area not only to the scientist but even to the ordinary man who cares to spend some time on the beach. As a result of the growing interest among marine naturalists in the life of organisms inhabiting the sea shore, we have today some authentic records on the subject from these ardent observers. However, these books have so far originated from the western countries. The lack of such a popular account on the sea coast of the eastern region has now been partly overcome by the publication of Dr. Chaung's book reviewed here.

Dr. Chaung, with his intimate knowledge of the Malayan coast, has endeavoured to present in his book some useful information. The book is divided into two main parts ; one deals with the sea shore and intertidal organisms and the other covers a systematic survey of the fauna. In doing so the author has followed but a conventional path. While a good amount of personal observations and scientific facts have been given it would appear that the book tends to follow more the pattern of a class-room text. On the other hand, in a book of this type greater emphasis should have been bestowed on the physical and biological aspects of the environment as a whole rather than on species morphology and systematics which are easily available from other sources. The general ecology has not been adequately brought out while a laboratory approach to the subject is sometimes more evident. Certain important animal groups, such as the annelids, which have considerable ecological significance and a cosmopolitan distribution, find only meagre mention in the book.

The aim of the author 'to illustrate the book with as many photographs as possible' has been amply fulfilled. All the photographs are excellent and well reproduced. However, the reader would have found it easier to refer to these figures at appropriate places as he reads along the text rather than to turn to the end of the book. The glossary and references are helpful. Despite the numerous art plates and good get-up, the price has been kept low enough to bring the book within reach of the many sea-shore naturalists who would find it a useful guide.

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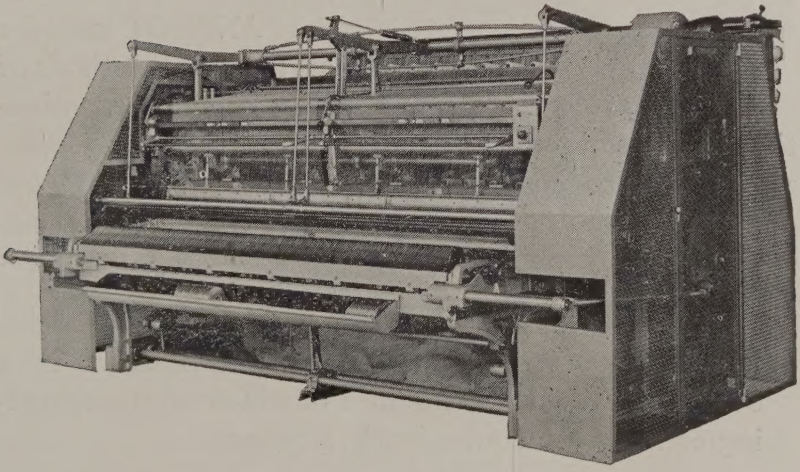

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